PB82-181082

Spreading Lagooned Sewage Sludge on Farmland: A Case History

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Purdue University
West Lafayette, Indiana

March 1982

U.S. Department of Commerce
National Technical Information Service
NTIS.

PB82-181082

EPA-600/2-82- 019
January 1982

SPREADING LAGOONED SEWAGE SLUDGE ON FARMLAND: A CASE HISTORY

by

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Contract No. C2575NASX

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PAGE NUMBER
EPA Form 2300-4 (4-80)

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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/2-82-019

2\.
ORD Report

3. RECIPIENT'S ACCESSION NO.
PB82 181082

4. TITLE AND SUBTITLE
Spreading Lagooned Sewage Sludge on Farmland:
A Case History

5. REPORT DATE
March 1982

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
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Purdue University, West Lafayette, Indiana

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
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10. PROGRAM ELEMENT NO.
CAZB1B, DU B-113, Task C/52

11. CONTRACT/GRANT NO.
C2575NASX

12. SPONSORING AGENCY NAME AND ADDRESS
Municipal Environmental Research Laboratory - Cin., OH
Office of Research and Development
U. S. Environmental Protection Agency
Cincinnati, Ohio 45268

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE
EPA/600/14

15. SUPPLEMENTARY NOTES
Project Officer: Gerald Stern 513-684-7654

16. ABSTRACT

This project demonstrated that land application is feasible and practical for a metropolitan treatment plant for disposal of a large volume (265,000 m^3) of stabilized, liquid sewage sludge stored in lagoons. The project involved transportation of sludge by semi-trailer tankers and either surface or subsurface application with conventional equipment to cropland. All sludge was applied on privately-owned land in an adjacent, rural county through a cooperative agreement between the farmer and contractor.

The report illustrates that the planning and conduct of a land application project requires expertise from a diversity of technical and sociological disciplines. Critical areas identified during this project included materials handling and transport, public relations, sludge application equipment, soils and crop production, soil, crop and ground water monitoring, sludge application and crop production scheduling, experience in relating to farmers and their problems, obtaining regulatory approvals, and establishing the mechanisms for flow of project data and information.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT
RELEASE TO PUBLIC

19. SECURITY CLASS *(This Report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES
116

22. PRICE

EPA Form 2220-1 (9-73)

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communication link between the researcher and the user community.

This report describes the development of a project involving the application of approximately 265,000 cubic meters of lagooned sewage sludge from a metropolitan area on privately-owned farmland in an adjacent, rural county. The sludge application project was initiated to enable use of the land occupied by the lagoons for expansion of the sewage treatment plant. The procedures developed will be valuable to those proposing to practice land disposal of stabilized sludge as part of the Nation's resource conservation program.

Francis T. Mayo, Director
Municipal Environmental Research
Laboratory

ABSTRACT

The City of Indianapolis, Indiana, was required to construct advanced wastewater treatment facilities at the Belmont Treatment Plant. The most cost effective site for these new treatment facilities was the 10 sludge lagoons containing 420,000 cubic meters (111 million gallons) of digested sewage sludge stored for up to 50 years. (Of the 420,000 cubic meters of sludge originally contemplated for disposal by land spreading, 265,000 cubic meters of this lagooned sludge was actually spread on land and the remainder disposed of in a landfill). The site preparation contract was awarded to a contractor who chose to dispose of the lagooned sludge by applying it to privately-owned agricultural cropland in adjacent Boone County, Indiana.

The project consisted of the following major tasks: (1) obtaining approval from regulatory agencies; (2) obtaining cooperation of landowners and farmers; (3) removing, transporting, and applying the lagooned sludge; and (4) monitoring the impact on crops.

Undefined state and federal regulations hampered initiation of the project. To determine appropriate rates for sludge application on cropland, extensive analyses of the lagoons were conducted. As expected, the solids content of the sludges was extremely variable, ranging from < 1% near the surface to > 30% at a 5 m depth. The cadmium (Cd) and PCB content of the sludges were major constraints in determining sludge application rates to cropland. The cadmium concentrations ranged from 122 to 241 mg/kg (average 179 mg/kg). Sludge application rates were initially based on 1.1 kg Cd/ha and later increased to 2.1 kg/ha. The maximum amounts of lead, zinc, nickel, and copper applied were less than 26, 48, 22, and 2.6 kg/ha, respectively. Corn and soybeans were the crops grown and a single application of sludge was made.

The subcontractor responsible for sludge application developed an effective public relations program involving demonstration plots, radio, and newspaper advertising, and written materials. Landowners consigned about 6,000 ha (15,000 acres) for sludge application. The subcontractor collected all soil samples, provided soil and sludge analysis data, and applied limestone if soil pH was below 6.5. The only resistance in Boone County originated from the installation of two temporary sludge storage lagoons.

The sewage sludge was resuspended in each lagoon, pumped into semi-trailer tankers, trucked to Boone County, and either applied immediately or placed in temporary storage lagoons. Because the application rate was based on cadmium levels in the sludge solids, frequent solids analyses were used to determine the appropriate application rate. A variety of equipment was used to surface apply or inject sludge into the soil. Adverse weather conditions reduced the time available for sludge application and thereby delayed project

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completion by several years. No measurable increases in the cadmium and PCB content of grain were found after a single sludge application.

During the course of this project, techniques evolved for removal, transportation, and application of lagooned sludges as well as procedures for administering and monitoring such a program.

This report was submitted in fulfillment of Contract No. C2575NASX by C. Michael Robson and Lee F. Sommers, under the sponsorship of the U. S. Environmental Protection Agency. This report covers the period of July 1, 1975, to December 31, 1980, and the work was completed as of June 1981.

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SECTION 1

INTRODUCTION

Disposal of sludge produced during municipal wastewater treatment is a severe problem. To select a disposal method, the operating agency must consider numerous factors including the following:

- Total costs, including capital investment, operation and maintenance
- Public health protection from direct contact with pathogens and contamination of the human food-chain with potentially toxic inorganic and organic constituents
- Pollution control, including water (ground and surface), air, and soils
- Public acceptance
- Resource conservation and recovery

Land application of stabilized sewage sludge has become a viable sludge management process. The potential benefits of this disposal method results from sludge serving as a low analysis fertilizer material and also as a soil conditioner.

This report is a case history of the utilization of anaerobically digested (stabilized) sewage sludge on agricultural land. Although the specific project described involved a single application of sludge to soils, it revealed much about equipment, procedures and regulatory agency requirements.

This case history describes the disposal of approximately 420,000 cubic meters (111 million gallons) of sludge and other materials that had been stored in lagoons at the Belmont Wastewater Treatment Plant which is owned and operated by the Department of Public Works of the Consolidated City of Indianapolis, Indiana. Of the 420,000 cubic meters of sludge originally contemplated for disposal by land spreading, 265,000 cubic meters of this lagooned sludge was actually spread on land and the remainder disposed of in a landfill. The sludge (stabilized by prolonged storage in the holding lagoons) and other materials were removed to enable the construction of new wastewater treatment facilities on portions of the Belmont site previously occupied by the sludge lagoons. The project history spans the period 1972 to 1980 (Table 1).

TABLE 1. PROJECT CHRONOLOGY

Date	Project Status
1972	
September 13	- Court Order requires City of Indianapolis, Department of Public Works (DPW) to upgrade Belmont and Southport wastewater treatment plants.
1973	
	- Pilot plant work carried out to select advanced wastewater treatment (AWT) process for Belmont and Southport treatment plants.
1974	
	- Pilot plant program completed for AWT processes.
	- Facility plan preparation for new site of the AWT plant.
1975	
March 11	- Facility plan submitted that recommended the construction of the Belmont AWT facilities on the site of existing sludge lagoons.
	- Initial bid documents prepared and issued for Belmont General Sitework Project including removal of sludge from lagoons 1 through 10.
October 21	- Initial bids for Belmont General Sitework opened.
	- DPW made tentative award to low bidder.
	- DPW rejected all bids as a result of a taxpayer's suit to allow off-site disposal of the lagooned sludge.
1976	
	- DPW prepared documents for rebidding of Belmont General Sitework allowing both on-site and off-site sludge disposal.

(continued)

TABLE 1 (continued)

Date	Project Status
1976	
November 23	- Bids received based on revised bid documents. Low bidder proposed land spreading of sludge in adjacent Boone County.
December 6	- DPW made tentative award to low bidder.
1977	
January 11	- Public hearing required as part of Environmental Assessment held in Boone County.
February 1	- Contractor submitted Environmental Assessment.
	- Resampling of sludge lagoons completed.
	- Analytical data from resampling of sludge lagoons evaluated by contractor and state regulatory agency.
May 23	- DPW issued qualified notice to proceed (no sludge to leave the Belmont Site) to contractor based on State and EPA qualified endorsement.
June 6	- Boone County citizens protested construction of interim sludge lagoons in Boone County.
June 16	- Restraining Order issued by Boone County judge halted interim lagoon construction.
August 31	- Agreement of understanding enabled recommencement of Boone County interim sludge holding lagoon construction.
September 26	- Indiana State Board of Health issued approval for land application. Land application of sludge in Boone County commenced.
November 28	- Sludge application ceased due to severe winter weather.

(continued)

TABLE 1 (continued)

Date	Project Status
1978	
May 29	- Sludge spreading started in Boone County.
June 13	- Sludge spreading stopped. Zoning problem precluded sludge hauling to interim lagoons.
August 8	- Zoning problem resolved and sludge hauling to interim lagoons recommenced.
September 25	- Sludge spreading started.
December 19	- The state approved an increase in cadmium loading rate from 1.12 kg/ha (1.0 lb./acre) to 2.1 kg/ha (1.875 lb./acre).
December 24	- Sludge spreading stopped.
1979	
October 5	- Sludge spreading started.
December 10	- Sludge spreading stopped.
1980	
October 11	- Sludge spreading started.
November 10	- Sludge spreading finished.
December 31	- Interim sludge holding lagoon sites restored to original condition.

SECTION 2

CONCLUSIONS

1. This project demonstrated that land application is feasible and practical for a metropolitan treatment plant to handle a large volume (265,000 cubic meters) of liquid sewage sludge stored in lagoons. The project involved transportation of sludge by semi-trailer tankers and either surface or subsurface application with conventional equipment to cropland. The sludge was applied on privately-owned land in an adjacent rural county through a cooperative agreement between the farmer and contractor.

2. The planning and conduct of a land application project requires expertise from a diversity of technical and sociological disciplines. Critical areas identified during this project included materials handling and transport, public relations, sludge application equipment, soils and crop production, soil, crop and ground water monitoring, sludge application and crop production scheduling, experience in relating to farmers and their problems, obtaining regulatory approvals, and establishing the mechanisms for flow of project data and information.

3. Delays in applying sludge were caused by adverse weather conditions. The growth of row crops (corn and soybeans) also minimized the number of days that sludge could be applied to soils. Coordination of crop production and sludge utilization programs is difficult due to uncertainties caused by adverse weather conditions.

4. A public relations program must be started very early in a project and must first obtain support of the agricultural community. Both the benefits and problems must be presented to all interested parties.

5. The project showed that numerous new procedures can be developed for monitoring sludge application rates, recording areas receiving sludge treatment, and maintaining a wide variety of records.

6. The equipment initially chosen for applying sludge did not perform as anticipated. Alternative equipment was selected which could withstand continuous use. All equipment should be evaluated on-site before purchase.

7. A single application of sewage sludge at a rate ranging from 1.12 to 2.1 kg Cd/ha did not cause measurable increases in the cadmium content of corn and soybean grain, nor was any plant uptake of PCB's observed.

8. If at all possible, off-site storage of sludge in either temporary or permanent lagoons should be avoided. It is far preferable to locate storage lagoons near the treatment plant and then transport sludge just prior to land application. The temporary storage lagoons located in Boone County resulted in the only negative public response to the land application project.

9. The project demonstrated that a large metropolitan sanitary district can transport and apply sludge to cropland in a neighboring rural area without widespread public resistance. To accomplish this goal, it was essential to involve local agricultural leaders, develop an effective and honest public relations program, utilize aesthetically acceptable methods for sludge application and develop sludge application procedures compatible with prevailing farming practices.

SECTION 3

RECOMMENDATIONS

1. Additional case histories are needed to describe projects using sludge application on cropland. Each report should emphasize public relations approaches, determination of sludge application rates, monitoring of soils, crops and groundwaters, and mechanisms for recording project information.

2. Studies are needed to evaluate sludge handling and application equipment.

3. Techniques should be developed to increase the effectiveness of public relations programs before a land application project is initiated. Variables influencing public acceptance require quantification.

4. Documentation should be developed to describe the relative health effects resulting from application of sewage sludge on cropland as compared with other disposal technologies. Even though minimal health risks have been shown in the past, a general fear of pathogens and toxic materials still exist in the minds of the public.

5. A manual is needed to describe the steps and procedures involved in establishing a land application program.

SECTION 4

BACKGROUND INFORMATION

INDIANAPOLIS WASTEWATER TREATMEENT PLANT EXPANSION

Indianapolis, Indiana, is one of the few major cities of the United States that is not situated on a large body of water to which it can discharge its liquid wastes. The White River, the major stream of the area, has a 10-year - 7 day low flow capacity of 135,475, cubic meters/day (35 mgd). Therefore, the City has provided activated sludge treatment to its wastewater since 1924 at the Belmont Wastewater Treatment Plant. The capacity of the Belmont plant has increased, over the years, to a capacity of 454,200 cubic meters/day (120 mgd). Additional wastewater flows are treated at the 211,960 cubic meters/day (56 mgd) Southport Wastewater Treatment Plant situated on the White River, some seven miles downstream of the Belmont Plant. Sludge from both plants is treated at the Belmont site.

Water quality sampling programs performed in the early 1970's indicated depressed dissolved oxygen levels some seventy miles downstream of Indianapolis. Although the City was discharging wastewater that received a high degree of biological secondary treatment, it was concluded that the degree of treatment was not sufficient to maintain the required dissolved oxygen levels in the White River downstream of Indianapolis. The negotiated Court Order of September 13, 1972, required the City to upgrade the level of treatment to maintain a daily average of 5 mg/l dissolved oxygen and a minimum of 4 mg/l dissolved oxygen downstream of Indianapolis. Construction of the new facilities was to be completed by May 1976.

A Facilities Plan for Advanced Wastewater Treatment Facilities at the Belmont and Southport Treatment Plants was prepared by the City's design consultant, as part of a Step 1 U. S. EPA Construction Grant Program requirement. The purposes of the facilities proposed in the Plan were to increase the capacity of the wastewater treatment plants and to upgrade the effluent quality in accordance with effluent standards. Pilot plant studies of various treatment processes were undertaken prior to completion of the Facilities Plan. Process additions and modifications included the nitrification of ammonia and improved removal of BOD_5 and suspended solids.

Since 1924, approximately 25 hectares (62 acres) of sludge lagoons have been constructed at the Belmont Wastewater Treatment Plant, to store the sludge or incinerator ash from the operation of the City of Indianapolis' wastewater treatment plants (Figure 1). Approximately 12 hectares (30 acres) of lagoon area, occupied by lagoons 1 through 10, were needed for the construction of the new treatment facilities. A cost analysis of possible sites

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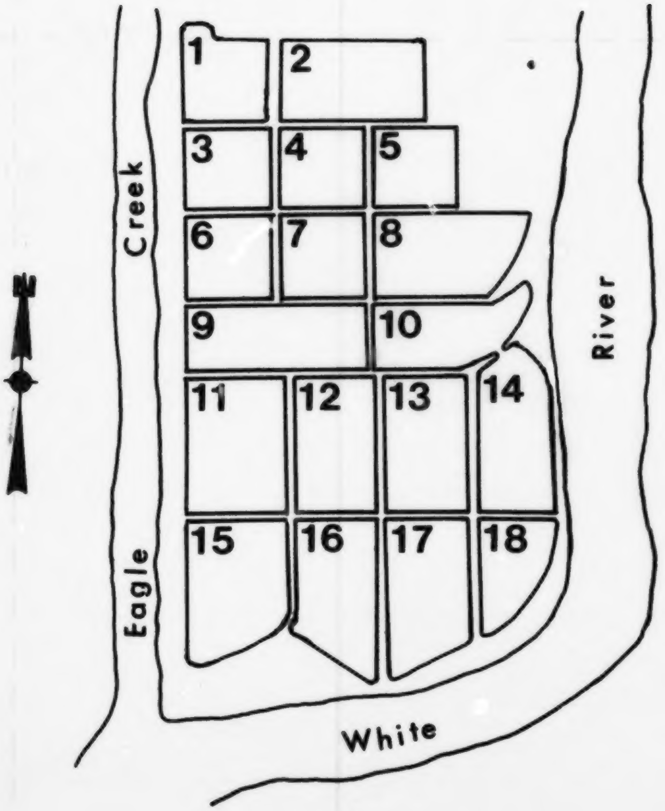
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Eagle Creek
White River

Figure 1. Sludge lagoons at the Belmont sewage treatment plant.

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for the new facilities indicated that the area occupied by the lagoons was the most cost-effective alternative.

The concept evaluated during the original design period was to chemically stabilize the sludge from the ten lagoons and dispose of it on the site of an old sanitary landfill at the north end of the Belmont treatment plant property. Plans and specifications were prepared based on this concept. However, an alternative sludge disposal method based on off-site disposal by application on agricultural land was added to the bid documents as a last minute, regulatory agency requirement. Bids were opened on October 28, 1975, but were later rejected by the Indianapolis Board of Public Works as a result of a taxpayer's suit. The suit was procedural and not related to the sludge disposal method.

Preparation of plans and specifications for rebidding of the General Sitework Project, which included the removal of contents of the sludge incinerator ash lagoons as well as the sludge lagoons, commenced early in 1976. Off-site disposal of the sludge by land application was reviewed critically. While the concept was philosophically attractive, it was recognized that there were few guidelines on which to prepare bid documents. Requirements of both state and Federal regulatory agencies were not clearly defined, particularly for possible disposal sites outside of Marion County in which the City is located, or even outside the State of Indiana. An additional on-site disposal method was considered which consisted of dewatering the contents of all 18 sludge and ash lagoons and then depositing the resulting sludge cake in lagoons 11 through 18. Because the funding agencies continued to require evaluation of off-site sludge disposal as an alternative, the plans and specifications prepared included the following four sludge disposal options:

1. Chemical fixation for on-site disposal
2. Sludge dewatering for on-site disposal
3. Off-site disposal by landspreading on agricultural land
4. Other off-site disposal methods

A copy of the specific section of the bid documents covering sludge disposal is included as Appendix A.

Eight bids, for various sludge disposal methods submitted by four contractors, were opened on November 23, 1976. The lowest responsible bidder's selected mode of sludge disposal was landspreading on agricultural land in adjoining Boone County, utilizing the services of subcontractors for hauling and applying the sludge. A tentative award was made to the low bidder by the Indianapolis Board of Public Works on December 6, 1977, subject to state and EPA financial and technical approval of the project.

The design engineer's analysis had indicated that the most cost effective means of sludge disposal was sludge dewatering for on-site disposal as previously described. However, the reality of the competitive bid process indicated, for this site and time specific case, that land spreading on agricultural land was the most cost effective method. The unit price quoted by the contractor for sludge disposal in Boone County was \$15.40/cubic meter(\$11.79/cubic yard) in terms of 1977 bid prices. This bid price included a \$54.30/hectare(\$22/acre) credit for sale of the sludge to farmers. The \$54.30/hectare charge to the farmers was waived after 1977 to avoid a zoning problem in Boone County.

BEHAVIOR OF SEWAGE SLUDGE COMPONENTS IN SOILS

Sewage sludges contain the major (nitrogen, phosphorus, and potassium) and minor (e.g., zinc, copper, iron) nutrients required by crops and thus can be readily substituted for conventional fertilizer materials. However, sewage sludges may also contain constituents which are potentially hazardous to plants or to animals or man after assimilation into crops. When considering application of sewage sludges on agricultural land, the sludge constituents of greatest concern are pathogens (human or animal), persistent organics (primarily chlorinated hydrocarbons), and heavy metals (e.g., lead, zinc, copper, nickel and cadmium). Most of these constraints can be overcome by proper management. The following section discusses general considerations for applying sewage sludge on cropland and incorporates the current U.S. EPA (10) regulations even though they were not in effect when the Belmont lagoon sludge project was being developed.

Pathogens

The majority of sewage sludges applied to agricultural land are treated by a process to minimize the potential for dispersal of pathogens, to reduce odors, and to control vectors. Typical sludge treatment processes include anaerobic or aerobic digestion, lime (CaO) treatment, extended storage in lagoons or on drying beds, and composting. In spite of these stabilization practices, sludges typically contain reduced levels of coliform organisms, bacterial pathogens (Salmonella, Shigella), protozoa (Entamoeba), helminthic parasites (Ascaris) and viruses (1). Disease transmission could conceivably result from sludge applications which contaminate crops consumed raw by humans (e.g., vegetables), adhere to forages grazed by animals or enter surface or ground waters through runoff or leaching. In all cases, the ability of the organism to survive in soils or on plant surfaces is a prerequisite for the existence of a health problem.

The survival of selected pathogens that may be present in sewage sludges has been recently reviewed (1). The majority of bacteria can persist for time periods ranging from several days to 10 months in soils or on vegetation. Ascaris ova are capable of withstanding adverse environmental conditions in soil resulting in survival for periods up to 7 years. The survival of viruses in soils amended with sewage sludge has not been adequately evaluated but viruses have been isolated from soils 8 to 13 days after sludge application (2,3). Several factors influence the survival of pathogens in soils including temperature, moisture, pH, sunlight, toxic substances, competitive organisms, and nutrient supply (4). Studies on the survival of salmonellae in soils indicate a survival time of 7 days in dry soils at 39°C (5). Survival was strongly influenced by interactions between soil moisture, temperature and inoculum carrier (waste or saline solution). Fecal coliforms added to crops through wastewater irrigation are retained in the upper 8 cm of the soil and exhibit a 10% survival over 48 hours (6). In addition, 10 hours of bright sunlight completely eliminated fecal coliforms on alfalfa forage (7). The application of sludge to cropland, managed to prevent erosion, has been shown to have minimal impact on the coliform and virus levels in both surface and ground waters (8). Except for Ascaris ova, the majority of sludge-borne pathogens will be at very low levels in soils amended with sludges after a one year period (1,9).

Proper management of a sludge application site is essential to minimize any potential pathogen related problems. Sludge application guidelines are being developed by numerous states as well as by the U. S. EPA (10). The current recommendations to manage pathogens can be summarized as follows (details provided in reference 10):

1. All sludges applied to soils growing human food-chain crops should be stabilized by a process which significantly reduces pathogens (i.e., aerobic or anaerobic digestion, lagooning, air-drying, heat-drying, composting, lime (CaO) treatment).

2. Stabilized sludges should not be applied to root or vegetable crops which can be consumed raw; root or vegetable crops can be grown on the site 18 months after sludge application.

3. Animals should not be grazed on pastures treated with sludge for one month after application.

Even though concern has been expressed about the addition of pathogens to soils in sludges, there has been no report of any significant disease problems associated with land application of stabilized sludges.

Persistent Organic Compounds

Many sewage sludges contain organic compounds, such as chlorinated hydrocarbons, which are relatively resistant to dcomposition in soils and are of concern from a human health standpoint. The chlorinated hydrocarbon pesticides and the polychlorinated biphenyls (PCB's) are the principal sludge-borne organic compounds receiving attention. A recent survey has indicated that the majority of sewage sludges contain relatively low concentrations (< 1 to 10 mg/kg) of these compounds although specific industrial inputs to the sewage system can result in elevated sludge levels (12). A recent survey of sludges produced in Indiana indicated that the median PCB concentration was 7 mg/kg (12) while sludges from Michigan typically contain < 1 mg PCB's/kg (13). Because PCB's are no longer being widely used for industrial purposes, the concentration in sludges should decrease with time.

Both chlorinated hydrocarbon pesticides (14) and PCB's (15) are resistant to rapid degradation in soils. For PCB's, the rate and extent of degradation increases as the percentage chlorine in the compound decreases (16). Even though chlorinated organics persist in soils, they are not generally assimilated by plant roots and translocated to above ground parts such as the grain or fruit. Elevated concentrations of PCB's were found in whole carrots grown in soils containing 100 mg PCB/kg of soil (17). However, 97% of the PCB was located in carrot peelings suggesting that physical adsorption to the root occurred rather than plant uptake. In addition, the carrot foliage did not contain detectable levels of PCB's. Similarly, essentially no plant uptake (orchard grass and carrot foliage) has been found when polybrominated biphenyls are applied to soils (18). Since PCB's are somewhat volatile, application of sludge to the soil surface could result in absorption of volatilized PCB's by plant stems and leaves (19). This mechanism of plant contamination with PCB's can be eliminated by incorporating sludge into the upper 10 to 15 cm of soil.

The principal problem arising from chlorinated hydrocarbons is direct ingestion by animals grazing on pastures where surface-applied sludge adheres to the forage. Research has indicated that sludge solids may constitute from 22 to 32% of the forage dry weight immediately following sludge application (19). The application of sludge to the stubble after removing the forage resulted in less contamination. Dairy cattle are most susceptible to PCB contamination of forages because PCB's are readily partitioned into the milk fat. The allowable level of PCB's in animal feedstuffs is 0.2 mg/kg and thus it is possible to calculate allowable PCB levels in sludge given a sludge application rate, forage yield, percent sludge retention on forages and an assimilation factor for the animal (21).

Based on the above considerations, the following recommendations are pertinent to managing PCB's and other persistent organics in land application systems:

1. Sludges containing > 10 mg PCB/kg should be incorporated into the surface soil (0-20 cm).

2. Sludges should not be surface applied on forages grazed by dairy cattle. For other animals, forages can be grazed 30 days after application.

Heavy Metals

The heavy metals of most concern when applying sewage sludge to agricultural land are lead, zinc, copper, nickel, and cadmium. Several studies have been conducted to determine the range of metals in various municipal sewage sludges (12,38,39). Although both domestic wastes and urban runoff contain metals, it is felt that industrial wastes contribute

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the majority of metals found in municipal sewage sludges and that industrial pretreatment can significantly reduce the metal content of sludges (22). This view is also supported by the low metal content of sludges from treatment plants serving only residential areas. It has been suggested that a "typical" domestic sewage sludge would contain 2,500 mg zinc/kg, 1,000 mg lead/kg, 1,000 mg copper/kg, 200 mg nickel/kg and 25 mg cadmium/kg (23). However, since sludge-borne metals added to soils accumulate in the plant root zone (upper 20 cm), heavy metal accumulation in soils is a consideration even when low metal sludges are applied to agricultural land.

The rationale for considering lead, zinc, copper, nickel and cadmium involves protecting the human food-chain from metal contamination and preventing the deterioration of soil productivity. Lead additions to soils are limited because of the potential for direct ingestion of lead contaminated soil or dust by animals or infants. It is well established that sludge applications do not result in appreciable increases in the lead content of crops (23,24). Even though copper and zinc are essential micronutrients for all crops, excessive additions of copper and zinc, along with nickel, can be toxic to plants resulting in undesirable depressions in crop yields. Fortunately, additions of sludge-borne copper, zinc, and nickel to soils will not pose a health risk to animals or humans because the plant concentrations of these metals which cause phytotoxicity are lower than those causing health problems (24).

Cadmium has received the greatest attention as a potential human health problem resulting from application of sewage sludges on cropland. Excessive cadmium levels can occur in plant tissues before crop yields are reduced. The concern over cadmium arises from current estimates of dietary cadmium intake by the U.S. population (26). After ingestion, cadmium accumulates primarily in the kidney and, after extended exposure to elevated dietary cadmium, a chronic kidney malfunction (proteinuria) may result (27). Thus, if sludge applications should significantly increase the cadmium content in the human diet, there is the potential for a health problem after 20 to 50 years. It should be noted that only 1 to 2% of the agricultural cropland is required for the annual application of all municipal sewage sludge produced in the U.S. (24). Consequently, dangers from cadmium uptake need to be considered, but they do not represent an imminent threat to human health.

Plant species differ markedly in their response to application of cadmium contained in sewage sludges. In general, leafy vegetables tend to accumulate greater concentrations of cadmium than fruit, tuber or grain crops. Also, the vegetative parts of most plants contain higher concentrations of cadmium than the reproductive or storage organs. Even though the leaf can contain elevated cadmium levels, only minimal increases in grain cadmium are observed for corn (22,24,28-30), suggesting that corn is an ideal crop for soils treated with sludge. Other grain crops, such as soybeans, oats and wheat, also exclude cadmium from entering the grain but to a lesser extent than corn (24). In addition to species differences in uptake of cadmium from soils, cultivars of corn (31), soybeans (32), and lettuce (33) vary in cadmium accumulation, indicating a potential for plant breeding programs to develop cultivars which are ideally suited for growth on soils amended with sludge.

In general, the concentrations of zinc in crops tend to parallel those of cadmium while copper and nickel are altered to a smaller extent by sludge applications (24). As with cadmium, zinc concentrations are greatest in the vegetative parts of plants rather than the fruit or grain. The effects of sewage sludge on the zinc and cadmium content of crops was discussed in a recent CAST report (56).

Soil properties exert a strong influence on the uptake of metals by crops. The solubility of heavy metals in soils is likely controlled by sorption onto clay minerals or hydrous oxides of iron, aluminum and manganese, chelation or complexation with organic matter and precipitation with phosphate, sulfide or carbonate anions (24). Either directly or indirectly, soil pH has a marked effect on the above metal retention mechanisms. Soil cation exchange capacity (CEC) is a function of soil clay and organic matter content and pH and has been used as an index of those soil properties minimizing metal solubility and thus plant uptake (34,35). However, recent studies indicate that soil CEC, per se, is not likely to influence cadmium concentrations in crops (36,37,56).

Soil pH appears to be the critical parameter for minimizing uptake of sludge-borne metals by crops. In most cases, substantial reductions in plant cadmium concentrations result from liming acid soils. Zinc concentrations in plants have been found to decrease from liming to a greater extent than cadmium in some crops. It is also apparent that crops differ in cadmium uptake following lime additions to increase soil pH. Metal uptake will be minimized by sludge applications to calcareous soil where the pH is continuously buffered by the presence of calcium carbonate. In addition, the cation exchange sites in soil organic matter are weakly acidic functional groups which serve to buffer soil pH. Thus, CEC may be important in non-calcareous soils by minimizing pH changes during the oxidation of reduced nitrogen and sulfur contained in sludges.

The U.S. EPA in addition to some state regulatory agencies have developed regulations concerning the maximum amounts of lead, zinc, copper, nickel and cadmium allowable on agricultural land used for growing food-chain crops. Food-chain crops are typically defined as those crops that can enter the human diet either with (wheat, corn) or without (leafy vegetables) processing. Researchers in the USDA and Agricultural Experiment Stations proposed limits for lead, zinc, copper, nickel, and cadmium which should allow the growth of all crops after termination of sludge applications, provided the soil pH is maintained at 6.5 or above (34). The metal loadings suggested are shown in Table 2. The use of soil CEC was based on the fact that metal solubility and thus, plant availability tends to decrease with increasing CEC in most soils of the north central United States. The CEC concept may be valid for copper, zinc and nickel but it does not appear to be related to the plant availability of cadmium (36,37). Scaling metal additions to soil CEC does not imply that sludge-borne metals are present in soils as exchangeable cations because it has

TABLE 2. MAXIMUM AMOUNTS OF LEAD, ZINC, COPPER, NICKEL AND CADMIUM THAT CAN BE APPLIED TO AGRICULTURAL CROPLAND* (34,35)

	Soil cation exchange capacity, meq/100 g		
Metal	<5	5-15	>15
	kg/ha		
lead	500	1,000	2,000
zinc	250	500	1,000
copper	125	250	500
nickel	125	250	500
cadmium†	5	10	20

*Soil must be maintained at pH 6.5 or above.

†Contained in U.S. EPA Criteria (10).

been well-established that nearly all metals in sludge-amended soils are nonexchangeable with a neutral salt (40,41).

The U.S. EPA has developed regulations only for cadmium additions to cropland (10). These limitations can be summarized as follows:

1. The pH of the soil/sludge mixture must be ≥6.5 at the time of sludge application.

2. Annual cadmium additions are limited to 0.5 kg/ha/yr if leafy vegetables, root crops, vegetables or tobacco are grown.

3. For other food-chain crops, the annual cadmium additions follow a phased reduction from 2 kg/ha/yr (present to 6/30/84), to 1.25 kg/ha/yr (7/1/84 to 12/31/86), to 0.5 kg/ha/yr (after 1/1/87).

4. The cumulative cadmium applied must be <5 kg/ha if the background soil pH is ≤6.5.

5. The cumulative cadmium applied is as shown in Table 2 for soils with a background pH ≥6.5 and for soils with a background pH ≤6.5 provided the pH is 6.5 at the time food-chain crops are grown.

For soils used for growth of animal feed only, neither annual nor cumulative cadmium application limits were established but soil pH must be 6.5 and a detailed facility plan is needed to prove that the crop will not directly enter the human diet. Guidelines rather than regulations have been established for lead, zinc, copper and nickel by the U.S. EPA (35). The U.S. EPA has also recently recommended that cumulative additions of lead to agricultural soils be limited to 800 kg/ha (58) rather than the values shown in Table 2.

Nitrogen

The factor limiting the annual application rate of many sludges is the available nitrogen content. A potential problem in land application of sludges is the leaching of nitrate below the plant root zone and ultimately into ground water. This can occur when available nitrogen additions to soils exceed the nitrogen requirement of the crop grown, whether the nitrogen added is from sludge, animal manures, or fertilizers. Thus, a well-designed system will use annual sludge application rates which are consistent with the nitrogen needs of the crop grown.

Several fractions of nitrogen in sewage sludge are available for plant uptake. In anaerobically digested sludges, ammonium constitutes from 25 to 50% of the total nitrogen while nitrate is present in only trace amounts (42). Both ammonium and nitrate are readily available for plant uptake. The organic nitrogen applied to soils in sewage sludge will undergo partial decomposition resulting in release of plant available inorganic nitrogen. The amount of organic nitrogen mineralization is usually estimated from laboratory or field decomposition studies which suggest that from 15% (43) to 20% (34) of the organic nitrogen is released the first year after application. In subsequent years, the percentage of organic N mineralized decreases.

Part of the nitrogen in sewage sludge applied to soils will be lost through volatilization or denitrification. Following surface application of sludges, up to 60% of the ammonium nitrogen can be lost through ammonia volatilization (44). Thus, the rate of sludge applied each year to provide adequate nitrogen for plant growth is greater for surface than incorporated applications (34,35). Nitrate losses can also occur after sludge application through denitrification (microbial reduction of nitrate to nitrous oxide and nitrogen gas under anaerobic conditions). This nitrogen loss is not corrected for directly but it has been considered in the development of conventional nitrogen fertilizer recommendations for various crops. Nitrogen fertilizer recommendations have been developed for the major crops grown in all regions of the U. S. and these values are used in determining the appropriate sewage sludge application rate for cropland.

Several field experiments have been conducted to compare yields of crops grown on soils fertilized with sewage sludge and conventional inorganic fertilizer materials (25,45,46,47). In general, crop yields are increased by increasing rates of sludge application. Corn grain yields have been determined on soils treated annually with ammonium nitrate and three different anaerobically digested sludges (47). Sludges applied at a rate of 200 kg N/ha gave similar corn grain yields as 100 kg N/ha added as ammonium nitrate. On a loamy sand soil, no yield response was obtained for either ammonium nitrate or sludge. The yield response of corn was similar for all three types of sludges. Soil analysis indicated that nitrate concentrations in the 0-15 cm depth averaged 92 and 59 mg N/kg for soils treated with 400 kg N/ha as ammonium nitrate and sludge, respectively. This study concluded that the optimum rate of sludge application was 200 kg N/ha for corn resulting in minimal leaching of nitrate into ground water. In a related study, it was shown that yields of both rye forage and corn grain increased with increasing sludge application rates (46). Corn grain yields were significantly increased for three years following a single application of sludge. This result is consistent with mineralization of organic nitrogen for several years after sludge is applied to soils. The studies cited along with others indicate that optimum yields of agronomic crops can be obtained with an appropriate rate of sludge application.

GENERAL DESIGN CRITERIA FOR LAND APPLICATION

As discussed in the previous sections, major considerations in the use of sewage sludge on agricultural land are: (1) pathogens; (2) persistent organics; (3) heavy metals - lead, zinc, copper, nickel and cadmium and; (4) available nitrogen. In addition, sludge applications should not result in contamination of surface waters as a result of runoff. This potential problem can be alleviated by incorporating the sludge into the soil, surface-applying sludge on only relatively level soils (i.e., <6% slope), and minimizing sludge application on frozen or snow covered soils. Additional information on other site selection considerations has been discussed in recent reviews (34,48,49).

The sludge utilization project described in this report was based on a single application of sludge to cropland. To design such a project, information was required on the (1) composition of sewage sludge; (2) chemical properties (plant available phosphorus and potassium, pH, and CEC) and fertility status of the soil and; (3) type and yield level of crop to be grown. Based on this data, sludge application rates and supplemental fertilizer needs were determined for the crops grown. Although not proposed by the contractor, the total amount of sludge that could have been applied over a period of years would have been based on cumulative additions of lead, zinc, copper, nickel and cadmium. This basic approach can be summarized as follows (50,57):

1. Obtain fertilizer (nitrogen, phosphorus and potassium) recommendation for crop grown based on soil test data.

2. If first sludge application proceed to step 3

   a. Correct fertilizer recommendation for amounts of residual nitrogen, phosphorus and potassium from previous sludge applications.

3. Select minimum sludge application rate from:

   a. Nitrogen limitation - sludge-borne plant available nitrogen (ammonium + nitrate + 20% of organic nitrogen) applied should equal corrected nitrogen fertilizer recommendation.

   b. Cadmium limitation - as specified in the U.S. EPA Criteria (10).

4. At the rate selected in step 3, calculate the amounts of phosphorus and potassium needed to optimize crop yield.

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5. Sum the lead, zinc, copper, nickel and cadmium added each year.

6. If a metal limit has been exceeded (Table 2) terminate sludge applications; otherwise, proceed to step I.

This approach assumes that soil pH is maintained at 6.5 or above whenever sludge is applied. Since the annual application rate is consistent with current fertilizer practices, monitoring in excess of routine soil testing for available phosphorus and potassium and pH is not required. It must be realized that the above steps only apply to sludges that have been stabilized by an appropriate process and that persistent organics (i.e., PCB's) are not present at concentrations > 10 mg/kg. Using this approach, sewage sludge can be readily used in the production of agronomic crops to obtain yields comparable to those from using conventional fertilizer materials.

GENERAL CHARACTERISTICS OF LAND APPLICATION AREA

The area chosen for sludge utilization was near Lebanon in Boone County, Indiana (Figure 2). The climate is characterized by a mean annual temperature of 12°C (53°F) and a uniform distribution of rainfall throughout the year (total precipitation of 99.1 cm (39 in). Snowfall ranges from 50.8 cm to 63.5 cm (20 to 25 in). The soils in the county were developed from glacial materials (Wisconsin glaciation) deposited in a nearly level till plain and some gently sloping moraines. In excess of 95% of the soils possess slopes of < 5%, resulting in minimal concern for surface runoff following sludge applications.

The soils and climate of the area are optimum for the production of grain crops such as corn, soybeans and winter wheat. These three crops account for > 90% of the acreage planted to agricultural crops with the majority being marketed as cash crops. Some corn and forages are also grown as feed for hogs and dairy and beef cattle. Although they are a function of soil fertility and management, the crop yields attainable are in excess of 9 metric tons corn/ha (150 bu corn/acre), 3 metric tons soybeans/ha (50 bu soybeans/acre), and 4 metric tons wheat/ha (70 bu wheat/acre). Previous research had shown that sewage sludge could be used as a fertilizer material for the crops grown in the area.

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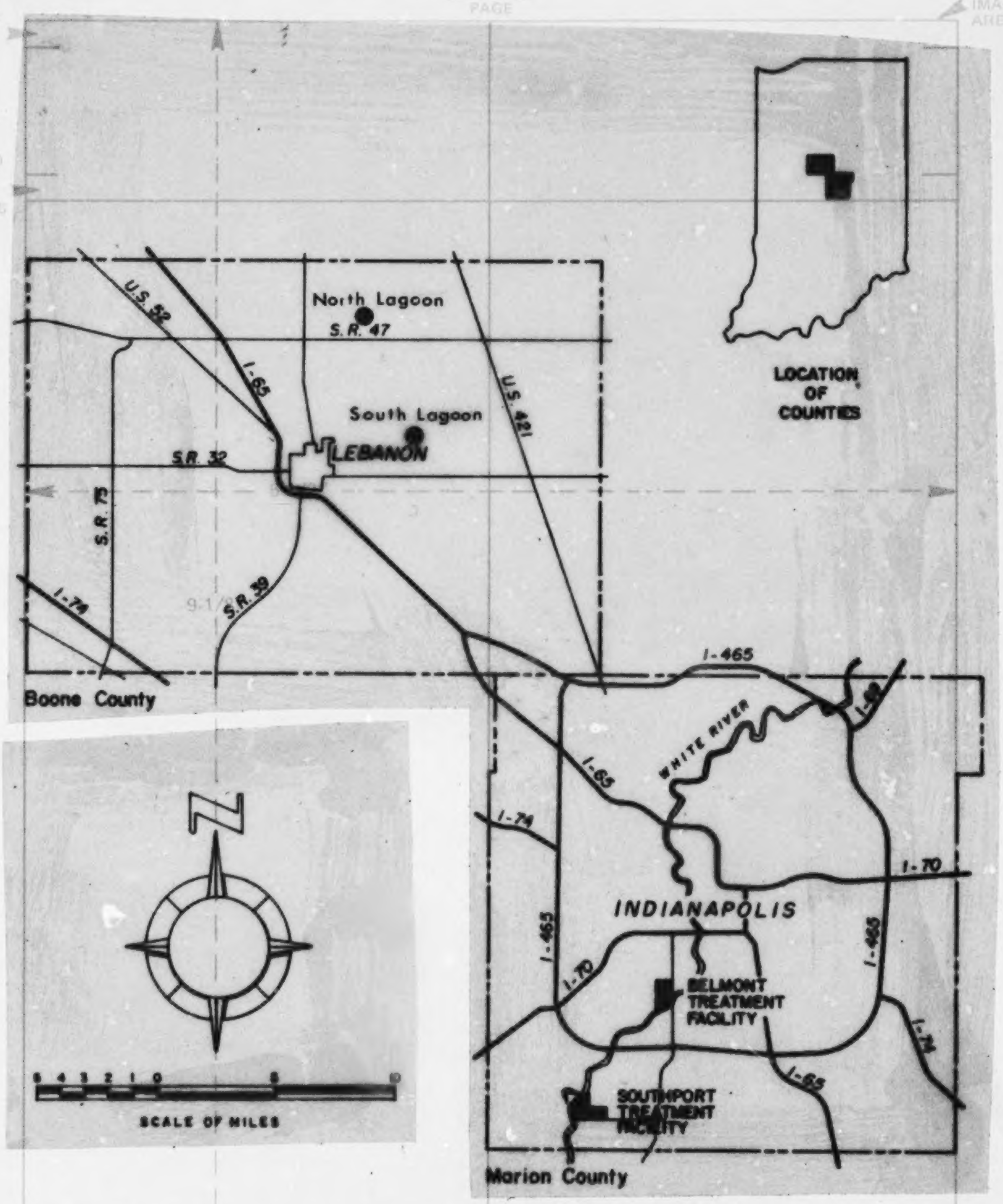
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I-65
U.S. 421
South Lagoon
LEBANON
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S.R. 75
S.R. 39
I-74
Boone County
LOCATION OF COUNTIES
I-465
WHITE RIVER
I-69
I-70
INDIANAPOLIS
BELMONT TREATMENT FACILITY
SOUTHPORT TREATMENT FACILITY
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Figure 2. General area map showing Belmont treatment facility and area of of sludge application.

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SECTION 5

REGULATORY AGENCY REQUIREMENTS

AGENCIES INVOLVED

Three public agencies were involved in development and implementation of the project, namely Boone County (Planning Board and Health Department), the Indiana State Board of Health (ISBH), and the U.S. Environmental Protection Agency (US EPA).

Local Agencies

Boone County agencies were generally receptive to the project. As reported in several newspaper articles, local officials believed that the proposed sludge application project was based on sound principles and did not constitute a threat to local farmland or water supplies. The County Sanitarian, however, was quoted as saying that studies conducted to date by the ISBH and the US EPA had not been conclusive enough to determine if the proposed project was safe or unsafe. Sludge was only applied on land zoned for agriculture so no zoning variances were needed.

The contractors initially intended to construct two temporary storage lagoons for holding sludge near the application areas when inclement weather prevented immediate applications on soils. Originally, it was planned that all sludge stored in the temporary lagoons would be applied to land operated by the owner of the lagoon. As such, the lagoon was not considered a place-of-business and no zoning changes were needed. However, due to an early winter in 1977 and a late and wet spring in 1978, the schedule for application of sludge on land and for removal of the sludge from the Belmont site was greatly delayed. A proposal was submitted by the contractor to the farmer owning the lagoon and to the local Planning Commission requesting that the additional sludge be stored in each lagoon and that this sludge be applied to land not controlled by the lagoon owner. This proposal was initially rejected by the farmer but he subsequently changed his mind and allowed the additional sludge to be stored in the lagoon and applied elsewhere. The Zoning Commission also approved this change of plans. As will be discussed later, construction of the temporary storage lagoons was the only phase of the project which prompted strong objections from the local citizens. In general, the contractors had established good rapport and credibility with local officials. They obviously felt that the contractors would perform the job as proposed and that adequate data had been collected on sludge and soil properties to prevent any adverse environmental effects.

Indiana State Board of Health

The Indiana Stream Pollution Control Board (SPCB) is the regulatory agency within the Indiana State Board of Health (ISBH) having authority to approve a land application project. Several ISBH professionals were knowledgeable on current practices and research involving application of sewage sludge on cropland. These individuals evaluated the various plans submitted by the contractors and made recommendations to the SPCB, who approve or disapprove all wastewater treatment projects in the state.

The contractor initially contacted the ISBH in 1975 to obtain information on current regulations and guidelines for application of sewage sludge on agricultural cropland. The ISBH did not have any formal regulations for land application of sludge, but some general guidelines had been developed by their technical staff. These guidelines were meant to be an aid in the selection of appropriate application rates for sludge on cropland. Because no regulations were in effect, each project proposal concerning land application of sludge was evaluated on an individual basis. As a result, the contractor was never confident that he was submitting the appropriate or needed information to the ISBH.

The ISBH was reluctant to give rapid approval for the project even though rather complete documentation had been provided by the contractor concerning (1) nitrogen, phosphorus, potassium, lead, zinc, copper, nickel, cadmium, PCB, and pathogen content of the sludge; (2) application rates to soils based on a maximum single addition of 1.12 kg cadmium/ha (1 lb/acre); (3) liming all soils to pH 6.5 to minimize metal uptake by plants; and (4) not applying sludge to frozen soils. At that time, U. S. EPA did not have any formal regulations concerning either cadmium or PCB applications to soils (these were not developed until September 1979 (10) and as a result, the ISBH could not receive any definitive guidance from either EPA Headquarters or from the EPA Regional Office. The ISBH was undoubtedly reluctant to set a precedent for rates of Cd and PCB applications to soils if the values selected were later found to be more liberal than those adopted by U. S. EPA. An additional factor was the gross PCB contamination of sewage sludge in Bloomington, Indiana. A local farmer had been applying PCB contaminated sludge (> 500 mg PCB/kg) on a pasture grazed by dairy cattle, resulting in the direct ingestion of sludge adhering to the forage and increases in the PCB levels in the milk. This highly publicized incident sensitized many individuals to the potential problem arising from PCBs in sewage sludge, especially when these sludges are applied to soils used for growing crops for human or animal consumption.

Prior to presenting the specific conditions placed on the project by the ISBH, it is informative to review the interim guidelines drafted by the ISBH in 1975. These were as follows:

1. General Limitations

    a. Sludge was to be stabilized by a process that reduced organic content by 40%.

b. Grazing of dairy cattle on pasture land treated with sludge was prohibited for 2 months.

c. Growing of food crops eaten raw (e.g., leafy vegetables and root crops) was prohibited for one year.

2. Site Selection.

a. The spreading site was to be located a minimum of 90 m (300 feet) away from inhabited dwellings and public roads, and a minimum of 450 m (1500 feet) from a residential development.

b. No sludge was to be applied within 90 m (300 feet) of wells, springs, intermittent streams, streams, rivers, ponds, lakes, or the high water marks of 10-year flood of any body of water.

c. A maximum slope of land surface for sludge disposal was to be 6.0%. When the ground slope was in excess of 6%, sludge was to be injected or incorporated into soil.

d. The minimum groundwater level from the surface was to be about 1 m (3 feet). However, areas of known crevices underlain with limestone was to be carefully evaluated.

3. Total Amount of Sludge Allowed.

The number of years sludge could be applied was based on cumulative amounts of zinc, copper and nickel to prevent reductions in crop yield and the cumulative amount of cadmium to minimize cadmium in food crops.

a. The zinc equivalent approach was used to calculate total allowable additions of zinc, copper, and nickel (the percent of the soil cation exchange capacity that could be added on a zinc equivalent basis). The zinc equivalent (mg per kg sludge) was calculated from: zinc equivalent = Zn + (2 x Cu) + (4 x Ni).

(It should be noted that even though the zinc equivalent is not currently used to determine total metal loading on soils; it was being discussed by US EPA and several state regulatory agencies in 1975 to 1977.)

b. Total cadmium additions could not exceed 11.2 kg/ha (10 lbs/acre).

4. Annual Sludge Application Rate

The maximum annual application rate was limited by either the nitrogen required by the crop grown or a 1.12 kg/ha (1 lb./acre) cadmium limitation.

a. The rate based on nitrogen considered the nitrogen requirement of the crop grown, the release of residual nitrogen from previous applications of sludge, and the amount of plant available nitrogen in the sewage sludge. The potential for nitrate leaching into ground water was minimized by limiting the amount of nitrogen applied each year.

b. If the cadmium/zinc ratio in the sludge exceeded 1%, then the annual amount of cadmium applied was not to exceed 1.12 kg/ha (1 lb./acre).

The state interim guidelines also contained guidance on management of spreading operations, monitoring and reporting, sludge and soil information to be provided and information on the sites used and sludge volumes applied.

U.S. Environmental Protection Agency

The passage of the Resource Recovery and Conservation Act encouraged the beneficial use of waste materials, including sewage sludge. In 1975, at the time the project was initiated and in 1976-1977, when state and federal approvals were sought, no definite regulations regarding application of sludge on cropland had been developed by US EPA. There was, however, considerable concern expressed by numerous individuals at the national and regional levels within US EPA concerning the potential harmful effects of increasing the cadmium and PCB levels in the human diet. Extensive research was being conducted by US EPA, US Department of Agricultural, and universities to determine the effect of sludge applications on the cadmium and/or PCB content of numerous crops. Although, the ISBH and SPCB received general guidance from US EPA, they did not provide specific values for acceptable application rates of cadmium and PCBs. Since US EPA Construction Grants funds were being used for the project, the land application plan required approval by Region V of US EPA.

In November of 1977, the Technical Bulletin (35) was published by US EPA. This document only provided guidance to the Construction Grants Program and did not constitute regulations. The Technical Bulletin did prove quite useful to the contractors in their request to increase the cadmium application rate from 1.12 kg/ha (1 lb./acre) to 2.1 kg/ha (1.875 lbs./acre).

FINAL REGULATORY AGENCY REQUIREMENTS

The SPCB issued an approval for beginning site work/sludge disposal by land application on April 19, 1977. This permit allowed awarding the contract prior to submittal of additional materials needed for final approval. The notice to proceed stipulated that additional information was to be submitted as follows:

1. Submittal by April 27, 1977, and approval by the ISBH and US EPA that "Conditions of Approval" had been satisfied for land application on remaining acreage.

2. Submittal by June 15, 1977, and approval by the ISBH and the US EPA that "Conditions of Approval" had been satisfied for land application on remaining acreage.

"Conditions of Approval" for construction as agreed to by EPA Region V and the SPCB to be met prior to a Notice to Proceed included the following:

1. The contractor will hold the original bid price.
2. Sludge from lagoons No. 6 and No. 16 shall not be used for land applications. This sludge must be disposed of on the Belmont Site.
3. Lagoons No. 1 through 10 shall be cleared and the area prepared for site work.
4. Sludge removed will be calculated and paid for, on the basis of vacated volume resulting from sludge removal (lagoons 1 through 10).
5. Only 1.12 kg of cadmium may be applied per hectare. Sludge application shall be for one year only and no second year application shall be made.
6. The amount and location of land used, the amount of heavy metals (nickel, copper, zinc, lead), PCBs, and cadmium applied shall be recorded at the County courthouse with respect to each parcel of land and shall be a permanent record transferred in the subsequent sale or transfer of the property.
7. All soil shall be tested for cadmium and heavy metals before applying sludge and recorded at the County courthouse with respect to each parcel of land and shall be a permanent record transferred in the subsequent sale or transfer of the property.
8. If pH of the soil is not at least 6.5, the pH must be adjusted to 6.5 before applying sludge.
9. Only corn and/or soybeans shall be planted the first year. Prior to harvest, representative samples of crop must be tested for PCB concentration and notification of the results provided to the EPA and Indiana State Board of Health.
10. No stalks shall be removed and no grazing of animals permitted for one crop year after application of the sludge.
11. No sludge shall be applied after the crop is planted.
12. Monitoring, recording and reporting of application rates shall be conducted as specified in the present contract.
13. Final payment will not be made until the temporary holding lagoon is cleared of sludge and filled in.

Additional state and US EPA conditions of approval were those presented at the January 11, 1977, Public Hearing as follows:

1. Application rates must were to be determined for each site based on both the sludge and soil characteristics.

2. A hold harmless agreement between the land owner and the State of Indiana was to be established.

3. Liability insurance or bond in an amount agreed upon in excess of one million dollars to protect the State of Indiana was to be purchased.

4. The sludge application rate was to be reviewed by the ISBH staff but the review of the application rate does not absolve the applicant from any liability, as the Board did not (as yet) recognize any application rate as being environmentally fool proof.

Also the City was reminded of a requirement of the original grant offer that:

> "...the grantee agrees to provide, concurrently with the submission of bidding information to the State, (1) Such supplemental environmental data, including, but not limited to, location, methodology, proximity of habitation, soil and groundwater characteristics,* etc., which otherwise were not addressed in the environmental assessment accompanying the application for the subject grant...".
>
> * To establish potential for groundwater pollution and need for lining the temporary holding lagoons.

CONTRACTOR'S RESPONSES TO REGULATORY AGENCY REQUIREMENTS

Sampling and Analysis of Sludge Lagoons

The contents of lagoons 1 through 10 had been sampled and analyzed as part of the Engineer's initial design effort. However, the sampling and analyses were performed at the time when sludge disposal was to be on the Belmont site. The results of Engineer's sludge sampling and analysis program were presented as part of the contract documents. The bidders were then required to verify the data provided with the bid documents.

One of the major problems encountered was obtaining satisfactory and consistent data for the chemical composition of the lagooned sludges. Sampling the lagoons was a major obstacle because the solids content increased with depth. The data presented in Table 3 illustrates the variability found in solids content for different sets of samples obtained from the lagoons. Some variations were also found for the heavy metal content of the sludge but it was substantially less than the 5 to 10 fold range found for the solids content.

TABLE 3. VARIABILITY IN THE SOLIDS CONTENT OF BELMONT LAGOON SLUDGES

LAGOON NUMBER	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4			
				0.8m	2.1m	3.6m	4.6m[a]
	% solids (wet weight)						
1	39.9	11.9	-	-	-	-	30.6
2	43.5	12.0	-	-	-	-	-
3	20.4	3.9	28.0	-	-	-	-
4	24.5	10.2	43.0	2.3	27.9	27.6	-
5	14.9	3.3	70.0	5.6	5.2	10.2	18.4
7	13.7	3.7	33.0	7.3	9.1	14.8	21.7
8	10.6	3.6	12.0	7.0	8.3	17.8	-
9	13.6	3.7	12.0	-	-	-	-
10	13.5	3.8	13.0	-	-	-	-
11	23.6	-	-	7.6	10.9	17.5	38.2
12	13.5	-	13.0	7.4	12.5	12.8	16.9
13	10.1	-	-	2.7	8.4	9.8	18.8
14	9.7	-	-	10.2	11.7	14.5	13.2
15	13.7	-	-	6.3	5.9	10.6	18.6
17	7.2	-	-	0.7	1.9	3.0	1.2
18	10.3	-	-	5.5	4.4	4.6	19.7

[a] Deepest sample ranged from 3.8m to 5.1m.

ISBH concerns regarding previous sampling and analytical procedures on which sludge application rates were to be based resulted in a January 19, 1977, meeting attended by representatives of US EPA, ISBH, the contractor, design engineer, and the City. After prolonged discussion, a sampling procedure was agreed upon to be performed by the contractor and monitored by representatives of the US EPA and the design engineer. The majority of the analyses were to be performed by the US EPA. Sampling was performed in February, 1977. The unseasonably cold weather proved beneficial as sampling could be performed through the 30 cm (12 inch) thick ice layer covering the lagoons. The majority of the analytical data were available by March 15, 1977, and are summarized in Table 4.

Contractor's Environmental Assessment Document

The bid documents required that the contractor take responsibility for preparation of an Environmental Assessment of sludge disposal involving sludge removal from the Belmont site. The responsibility for preparation of this document was accepted by the general contractor's sludge disposal subcontractor.

The Environmental Assessment by the sludge disposal subcontractor satisfied the regulatory requirements of such a document. It compared the proposed sludge disposal method to other alternatives listed in the bid

TABLE 4. CHARACTERISTICS OF BELMONT LAGOON SLUDGES*

Lagoon Number	Total Solids	Total Volatile Solids	Total N	Ammonium N	Nitrate N	Total P	Total Al	Total Ba	Cyanide	Fecal Coli Forms
	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	$MPN/100 \times 10^{-3}$
1	39.9	29.0	1.50	1.50	<0.01	1.20	0.84	0.12	31	0.2
2	43.5	29.5	1.50	0.45	<0.01	1.10	0.73	0.08	46	0.2
3	20.4	33.3	1.80	0.51	<0.01	2.10	1.52	0.11	87	0.2
4	24.5	29.0	1.50	0.26	<0.01	2.20	1.55	0.09	74	4
5	14.9	36.5	1.70	0.55	<0.01	1.10	0.87	0.10	43	460
6	13.2	40.3	2.00	0.68	<0.01	2.40	1.57	0.10	100	75
7	13.7	39.4	2.30	0.72	<0.01	2.50	1.28	0.10	100	93
8	10.6	48.0	2.70	0.86	<0.01	2.60	1.15	0.09	140	2,400
9	13.6	43.8	2.60	0.87	<0.01	2.30	1.25	0.10	130	75
10	13.5	44.2	2.50	0.82	<0.01	2.20	-	0.09	110	2,400
11	23.6	53.3	1.50	0.47	<0.01	1.40	1.00	0.11	52	4
12	13.5	39.8	2.20	0.84	<0.01	2.10	1.05	0.09	150	43
13	10.1	41.3	2.60	0.95	<0.01	2.50	1.30	0.11	130	11
14	9.7	45.7	3.10	0.98	<0.01	2.60	-	-	170	460
15	13.7	48.9	2.10	0.79	<0.01	1.40	1.12	0.11	130	2.4
16	7.9	46.8	3.00	1.01	<0.01	2.30	1.11	0.10	170	4
17	7.2	43.6	3.00	1.20	<0.01	2.40	1.23	0.10	150	460
18	10.2	45.5	2.80	0.92	<0.01	2.60	1.14	0.09	92	460

* All data expressed on an oven-dry solids basis except for total solids.

TABLE 4 (continued)*

Lagoon Number	Total PCB	Total Pb	Total Zn	Total Cu	Total Cd	Total As	Total Co	Total Cu	Total Mn	Total Fe
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1	<3	1,410	>650	909	122	50	51	543	398	2.37
2	21	1,510	1,810	918	123	20	49	547	619	2.21
3	9	1,940	3,040	1,410	241	15	57	1,010	467	2.48
4	17	1,450	>630	1,300	174	50	50	960	432	2.20
5	11	1,370	2,590	1,130	124	25	63	967	400	2.30
6	60	1,080	3,370	1,390	178	20	67	1,420	517	2.46
7	20	1,480	3,260	1,490	166	25	50	1,210	458	2.05
8	24	1,240	3,270	1,520	144	15	58	1,360	440	2.27
9	22	1,340	3,000	1,540	202	23	58	1,460	437	2.58
10	26	1,490	2,870	1,540	157	25	49	1,080	392	-
11	26	1,490	2,850	1,320	207	24	62	1,190	444	2.73
12	17	1,510	2,810	1,330	187	26	48	1,330	363	2.16
13	41	1,550	3,270	1,570	200	21	58	1,420	503	2.45
14	24	-	-	-	-	24	-	-	-	-
15	18	1,790	3,100	1,550	240	27	63	1,440	465	2.71
16	66	1,110	3,220	1,520	259	30	58	1,950	473	2.51
17	30	1,230	2,990	1,450	188	23	54	1,440	493	2.25
18	22	1,270	3,370	1,710	192	30	51	1,600	467	2.26

* All data expressed on an oven-dry solids basis.

documents. Procedures were described for transporting sludge to Boone County and for application to agricultural land. A price of about $54.30/hectare ($22/acre) for one application of sludge was quoted to the farmers.

The public hearing required by the Environmental Assessment procedure was held in Boone County on January 11, 1977. Formal statements concerning the project were presented by representatives of the Indiana State Board of Health (ISBH). Statements made by the sludge spreading subcontractor at the hearing established many of the constraints which were to affect the sludge disposal procedure throughout the contract. The tone of the public hearing was favorable to the landspreading project.

The struggle to obtain and retain regulatory and funding agency approvals was a continuing effort throughout the life of the project. The City's submission of the contractor's Environmental Assessment and associated documents was only the first of the innumerable submissions and associated meetings and hearings that were required to enable the construction work to first commence and then to continue.

The contractor was not experienced or prepared to respond rapidly to the continuing requirements of the regulatory agencies for "further information." The City and its consultants were, therefore, required to review, edit, and expedite the contractor's responses to the agencies.

The City's attempt, by the contract documents, to assign the contractor all responsibility for obtaining and maintaining regulatory agency approvals failed. The regulatory agency approvals maintained that the City was responsible for the sludge almost in perpetuity and therefore the City could not assign its responsibility to the contractor.

Construction of Interim Sludge Lagoons

The Environmental Assessment documents submitted by the contractor, as part of his bid, called for an off-site interim sludge lagoon to be constructed in Boone County. The proposed lagoon was to be used to hold sludge which could not be immediately spread on the land and was to be located on the Morton farm (North Lagoon) as shown in Figure 2. The prolonged period required to obtain the regulatory agency approvals in early 1977 made it clear that additional off-site sludge storage capacity would be required. The contractor therefore proposed to construct a second interim sludge storage lagoon on the Duffield property (South Lagoon) as shown in Figure 2.

The ISBH required the submission of the construction and monitoring information prior to construction of the two interim sludge lagoons. Percolation tests were devised to determine whether a clay liner would be necessary. It was found that sludge completely sealed the soil surface. Monitoring wells were required on all sides of the temporary holding ponds with the following analyses to be performed on a monthly basis: (a) ammonium; (b) nitrite + nitrate; (c) iron; (d) chloride; (e) conductivity; (f) pH (on-site); (g) PCB's; (h) zinc; and (i) total organic carbon. Review of data obtained over the period of the project showed no significant variations in the water quality parameters measured.

The contractor continued to gather and prepare information for submission by the City to the ISBH in response to the requirements of the Indiana Stream Pollution Control Board letter of April 19, 1977. During this period two 85,165 cubic meter (22.5 million gallon) temporary sludge holding lagoons were being constructed in Boone County. One reaction to this construction was the June 16, 1977, filing of a restraining order by 34 residents of Boone County. Despite the fact that more than three months were to pass before any sludge was to leave the Belmont Plant, the plaintiffs alleged that sludge was already being hauled to Boone County and that:

> "That said sludge attracts insects, fouls the air, and said materials contained in the sewage are being percolated through the soil and are reaching the water tables that the aforementioned plaintiffs use to drink via wells located within their geographic area."

and

> "That due to the location of the sludge pond at 250 N. 400 East, the adjoining landowners, and the individuals who reside within that geographic location cannot go outside due to the smell and due to the great inflow of disease bearing mosquitoes and same is creating a health and nuisance hazard to said location."

A Court hearing on August 31, 1977, resulted from the plaintiffs' request for a restraining order. An Agreement of Understanding resulted from discussions between the attorneys for the various parties. The salient requirements of the Agreement of Understanding were as follows:

1. All sludge to be removed from the South lagoon and site restored to its original condition on or before December 31, 1979.

2. Only sludge from the Belmont Plant to be transported to the South or North lagoons. Sludge hauling to be completed within 150 days of first day of hauling.

3. Water samples to be collected periodically from test wells located on all four sides of both lagoons for analysis by the ISBH.

4. All sludge to be removed from either or both lagoons if ISBH finds that leakage from the lagoon is endangering the water supply of adjoining property owners.

5. Only the sludge involved in the current contract with the City shall be transported to or stored in the lagoons.

6. "No "raw sewage with excrement odor" to be stored in the lagoons.

7. The ISBH will collect samples from the plaintiffs' wells as soon as possible and will continue periodic sampling.

The ISBH issued a letter approving landspreading of 1053 hectares (2602 acres) on August 30, 1977, which was subsequently endorsed by US EPA letter of September 8, 1977. The erratic availability of these areas discouraged the contractor from starting to haul off-site until ISBH approval of the two lagoons was issued on September 15, 1977, endorsed by the US EPA letter of October 13, 1977. Based on the verbal assurance of US EPA endorsement of the State project approvals, the first load of sludge left the Belmont site on September 26, 1977.

Documentation of Land Application Sites

Prior to transportation of sludge from the Belmont lagoons to Boone County and application on agricultural land, the contractor began collecting the necessary information for compliance with the requirements set forth by the SPCB. The information needed included:

1. Letter of intent describing the sludge application program (including sludge analysis) and stating the land area involved was signed by the owner and/or operator (Appendix C).

2. Release form was signed by the owner and/or operator (Appendix D).

3. A large scale, detail map (2.5 cm = 200/m; 1 in = 660 ft.) showing setback distances, inhabitated dwellings, roads, and area for surface or incorporated sludge application was submitted for each site.

4. Soil analysis was performed on each individual field to be treated with sludge. All soil samples were collected by the contractor and sent to a commercial laboratory. The analyses performed on each soil sample included: a) organic matter; b) plant available phosphorus and potassium; c) pH and lime requirement if pH <6.5; d) exchangeable potassium, sodium, calcium, magnesium and hydrogen (the sum equals cation exchange capacity) and; total zinc, lead, copper, nickel and cadmium.

The location of soil sample collection and sludge application was also identified on a copy of the soil survey map. The soil survey map also contained the needed information on slopes. If desired, it was then possible to correlate the results of soil analysis with the soil series. Each owner/operator was assigned a permanent identification number to facilitate data handling. The area available for an owner/operator was tabulated on a master sheet. Examples of the various forms and maps used are shown in Appendix E.

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SECTION 6

AGRONOMIC CONSIDERATIONS AND PUBLIC RELATIONS

AGRONOMIC CONSIDERATIONS

The contractor's program involved a single application of sludge on cropland. The elevated cadmium concentrations in the lagoon sludges precluded the application of sludge at a rate which satisfied the nitrogen demand of the crop. Initial approval of the project was based on limiting cadmium additions to soils at 1.12 kg/ha (1 lb/acre); this rate was later increased to 2.1 kg/ha (1.875 lbs/acre). Because the sludge cadmium concentrations varied for each lagoon, the application rate ranged from 4.6 to 9.2 metric tons/ha (2.1 to 4.1 tons/acre) at 1.12 kg Cd/ha (Table 5) and from 8.7 to 17.1 metric tons/ha (3.9 to 7.7 tons/acre) at 2.1 kg Cd/ha (Table 6); sludge composition data are shown in Table 4.

The amounts of plant available nitrogen and total phosphorus, lead, zinc, copper, nickel and PCB's applied in a single application of lagoon sludges are shown in Tables 5 and 6. Soil analysis was conducted on each field treated with sludge so the plant available levels of phosphorus and potassium in each soil were known. Because plant available phosphorus levels ranged from low to very high, representative phosphorus fertilizer additions are shown in Tables 5 and 6. Soybeans are not fertilized with nitrogen because they can "fix" atmospheric nitrogen. If supplied with an external source of nitrogen, soybeans actually have the capacity to assimilate greater quantities of nitrogen than corn. For a corn yield of 9,400 kg/ha (150 bu/acre), the amount of plant available nitrogen applied in the lagooned sewage sludge satisfied from 20 to 80% of the nitrogen requirement. The phosphorus requirements of both corn and soybeans can range from 10 to 25% of those for nitrogen. As a result, a single sludge application should provide sufficient phosphorus for 2 to 3 cropping seasons. The sludge contained low concentrations of potassium resulting in essentially no change in the potassium fertilizer needed to optimize crop growth.

In general, the major benefit obtained from the single application of sludge was a significant increase in plant available phosphorus. A portion of the nitrogen required by corn was also satisfied by sludge additions. Other benefits derived from sludge application was the addition of nearly all trace elements required by corn and soybeans. A single application of sludge provided significant amounts of zinc, copper, cobalt, iron, and manganese, relative to the requirements of corn and soybeans.

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TABLE 5. APPLICATION RATE FOR LAGOON SLUDGES BASED ON A 1.12 kg CADMIUM/ha LIMIT AND THE AMOUNTS OF NITROGEN, PHOSPHORUS, LEAD, ZINC, COPPER, NICKEL AND PCB's APPLIED

Lagoon Number	Applic. Rate	Plant Avail. N[a]	P	Pb	Zn	Cu	Ni	PCB
	metric tons/ha		kg/ha					
1	9.2	39	111	13	24	8	0.5	0.028
2	9.1	60	100	14	16	8	0.5	0.191
3	4.6	36	98	9	14	7	0.5	0.042
4	6.4	33	142	9	17	8	0.6	0.109
5	9.0	70	99	12	23	10	0.6	0.099
7	6.7	70	169	10	22	10	1.1	0.135
8	7.8	96	202	10	25	13	1.4	0.187
9	5.5	67	128	7	17	8	0.9	0.122
10	7.1	82	157	11	20	11	1.1	0.185
11	5.4	37	76	8	15	7	0.6	0.141
12	6.0	67	126	9	17	8	0.6	0.102
13	5.6	72	140	9	18	9	1.1	0.230
15	4.7	49	65	8	14	7	0.6	0.084
17	6.0	93	143	7	18	9	1.0	0.179
18	5.8	76	152	7	20	10	1.1	0.128
Fertilizer applied for corn or soybeans[b]		220[c]	35	-	-	-	-	-
Suggested allowable addition[d]		-	-	1,000	2,000	250	250	-

[a] 100% of NH_4^+-N plus 20% or organic-N

[b] Typical fertilizer applications assuming medium soil test levels for P and K; crop yields of 9,400 - 11,000 kg/ha (150-175 bu/acre) for corn and 3,360 - 4,000 kg/ha (50-60 bu/acre) for soybeans

[c] N fertilizer not applied to soybeans due to symbiotic N_2 fixation

[d] Total metal additions suggested by U.S. EPA (1977), for a CEC of 5-15 meq/100 g

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TABLE 6. APPLICATION RATE FOR LAGOON SLUDGES BASED ON A 2.1 kg CADMIUM/ha LIMIT AND THE AMOUNTS OF NITROGEN, PHOSPHORUS, LEAD, ZINC, COPPER, NICKEL AND PCB's APPLIED

Lagoon Number	Applic. Rate	Plant Avail. N[a]	P	Pb	Zn	Cu	Ni	PCB
	metric tons/ha		kg/ha					
1	17.2	72	208	24	46	16	0.9	0.052
2	17.1	113	188	26	31	16	0.9	0.359
3	8.7	67	183	17	26	13	0.9	0.078
4	12.1	61	266	17	32	16	1.1	0.205
5	16.9	132	186	23	44	19	1.1	0.186
7	12.6	131	316	19	41	19	2.1	0.253
8	14.6	179	379	18	48	22	2.6	0.350
9	10.4	126	239	14	31	16	1.7	0.229
10	13.4	155	294	20	38	21	2.0	0.348
11	10.1	69	142	15	29	13	1.0	0.264
12	11.2	125	236	17	32	15	1.1	0.191
13	10.5	134	263	16	34	16	2.0	0.431
15	8.7	92	122	16	27	14	1.1	0.157
17	11.2	174	268	14	33	16	2.0	0.335
18	10.9	142	284	14	37	19	2.1	0.241
Fertilizer applied for corn or soybeans[b]		220[c]	35	-	-	-	-	-
Suggested allowable addition[d]		-	-	1,000	500	250	250	-

[a] 100% of NH_4^+-N and 20% of organic-N

[b] Typical fertilizer applications assuming medium soil test levels for P and K; crop yields of 9,400 - 11,000 kg/ha (150-175 bu/acre) for corn and 3,360 - 4,000 kg/ha (50-60 bu/acre) for soybeans.

[c] N fertilizer not applied to soybeans because of symbiotic N_2 fixation

[d] Total metal additions suggested by U.S. EPA (1977) for a CEC of 5-15 meq/100 g

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The amounts of PCB's (polychlorinated biphenyls) applied are also presented in Tables 5 and 6. The concentration of PCB's in the sludges ranged from 20 to 30 mg/kg, values in excess of those found in most sludges. After application, the concentrations of PCB's in the soil were calculated to range from 0.01 to 0.18 mg/kg. These levels were not anticipated to have an adverse affect on crop quality.

Even though the sludges contained relatively high concentrations of lead, zinc, copper and nickel, a single application did not approach the limitations suggested by U.S. EPA (Tables 5 and 6). The metal limitations were designed to prevent the development of phytotoxicities from zinc, copper and nickel and the contamination of crops with lead. If the project had been designed for annual applications of sludge until a critical accumulation of metals occurred, cadmium would still have controlled the total allowable amount applied to agricultural cropland rather than lead, zinc, copper or nickel.

PUBLIC PARTICIPATION AND PUBLIC RELATIONS

Two sectors of the community were addressed during development of the sludge utilization program. The first group was the farmers who are receiving the sludge. They must see an economic benefit to the use of sludge, an unknown quantity in their mind, when compared to conventional fertilizer materials. Secondly, the fears and objections of the farmers' neighbors were addressed. The initial response to a sludge application project may be similar to that when a new landfill site is discussed - yes, we need a new landfill, but not near my property.

The most common objections or concerns to use of sludge on cropland include: a) fear of odors; b) concern about toxic effects to land and contamination of wells with toxic chemicals; c) resentment about a sophisticated sales approach (lacks credibility); d) insufficient data to support the benefits claimed for land application; e) reports of excess applications by other projects resulting in decreased crop yields or odor problems and; f) complaints will not be handled courteously or rapidly. Above all, there may be a general feeling that a large city is trying to dump its problem on a small, rural community.

The contractor realized that an effective public relations program was essential to insure acceptance of sludge utilization in Boone County. Even though a technically sound sludge application system may be designed, public opposition could prevent the program from being initiated. The contractor's public relations approach was to present all available information, both positive and negative, to the general public and especially to the farmers who were directly involved in the project. To understand such a recycling approach, the general public must be educated on sludge utilization and they must also have direct input into developing the project. Factual information can be conveyed by personal contacts, public hearings and educational meetings, newspaper articles, and radio and/or television releases. Above all, the information must be technically sound and it must equally emphasize the positive and negative aspects of sludge use on cropland.

The public relations approaches utilized by the contractor can be summarized as follows:

1. Individual and group meetings were held with many farmers interested in using sludge on their cropland.
2. Meetings were held with the County Planner and County Sanitarian of Boone County, Indiana.
3. Interviews were conducted with the Lebanon Reporter, the newspaper with the largest circulation in Boone County.
4. Interviews were conducted with radio station WNON of Lebanon, Indiana, resulting in news broadcasts.
5. Meetings were conducted with all agricultural extension agents in Boone County and surrounding areas. Representatives from the Indiana State Board of Health, the consulting engineer firm and Purdue University were present at many of these meetings.
6. A public demonstration of sludge application on cropland was held in November, 1975. This demonstration involved the application of Belmont sludge at the planned 8.96 metric ton/ha (4 tons/acre) rate on farmland in Boone County. Equipment with high flotation tires was used to apply the sludge. Approximately 200 people attended the demonstration including county officials, members of the press, and other interested parties. Information describing the chemical composition of and application rates for Belmont lagoon sludges, along with copies of press releases and extension bulletins, was given to all people attending the demonstration. The demonstration was advertised by: a) a quarter page ad in the Lebanon Reporter; b) spot announcements on radio station WNON, Lebanon, Indiana, and; c) News article in Lebanon Reporter 5 days before the demonstration.
7. A public relations firm located in Indianapolis, Indiana, was retained to develop news releases and other public participation programs.
8. Prior to the public hearing in January, 1977, a letter describing the sludge utilization project was sent to numerous environmental, service, and governmental organizations. This letter urged their attendance and input into the program. A partial list of organizations contacted included:

Indiana Coal Association
Department of Natural Resources
TV and radio reporters
Newspaper reporters
Farm Bureau Co-op
Soil Conservation Service
Extension Agents
North Side Environmental Action Committee
League of Women Voters
Indiana Assoc. of Cities and Towns
Boone County Board of Zoning and Appeals
Nature Conservancy
Indianapolis Environmental Action
Local Bankers
Consulting Engineers
Indiana State Board of Health
County Sanitarian
News wire services
Izaah Walton League
Save the Dunes Council
Audubon Society
Indiana Conservation Council
Coalition for the Environment
Lafayette Environmental Action Federation
Citizens Organized to Protect our Environment
Sierra Club

9. Development of written materials for distribution to anyone interested in the sludge application project. This material described the company involved, sludge composition, rates of application, potential problems, cost and liability insurance. Examples of this information are included as Appendix B.

One of the major factors in the above program was the direct involvement of a local farm management firm. This organization had been in business in the Lebanon area since 1939 and as a result was respected and trusted by local farmers. Farmers were likely more receptive to the program since a local firm was directly involved in the daily operations of the project. Their attitude might have been different had the project been controlled by a "big city" firm. Furthermore, the farm management firm was directly involved with farming 75% of the land area subscribed for application of sludge.

Essentially no objections were raised concerning the application of sludge on cropland by either the farmers or neighbors. However, the proposal also involved the construction of two temporary storage lagoons on land controlled by the farm management firm (Figure 2). The lagoons elicited a strong negative response not from the farmers but from the neighbors. They felt that the lagoons would cause significant odor problems and contamination of local wells used for drinking water. The concerned citizens obtained an attorney and filed an injunction to halt construction of the temporary storage lagoons. Even though the contractors presented technically sound answers to questions and concerns raised by the citizens, the emotional nature of the issue precluded a rational settlement. The public attitude was undoubtedly influenced by information presented in local newspaper reports such as the following:

> "A person at the meeting said they were concerned about water lines, wells, and streams.

Ball said, "They (Organic Materials) have to prove to us if the lagoons are safe, or not. All we hear is bad stuff. They have to convince us it is safe".

About the same people were on hand last night as those who assembled Wednesday night at the lagoon site east of town where Duff, president of Organic Materials, and John Tait, vice president, fielded a myriad of questions but remonstrators were not satisfied with the answers.

Mrs. Sam Rogers last night reported that a relative near Arcola, Ill., was in close proximity of a similar lagoon and that at times the odor was bad. The relative, this morning via telephone conversation with this reporter, said that there was some concern that the crops would take up undesirable elements out of the thick, heavy liquid, but that he had recently read some article on this and no conclusion had been reached that the crops take up enough to be harmful. "Your Boone situation may be different," he said, "but at times the odor was bad." However, the Illinois farmer, who was about three miles from the lagoon, said that at times there were some little problems with wells nearby and drainage ditches.
But he concluded the Soil Enrichment Materials Company, which hauled the waste material out of Chicago and spent millions of dollars installing rail lines and buying land, went bankrupt and the lagoon, still full, has been abandoned."

This article alludes to the contamination of streams and wells by the sludge lagoons. Even though such claims were never substantiated, the fear of such contamination had a substantial impact on people's attitudes. The article also mentions uptake of "undesirable elements" by crops in spite of the fact that the contractor had spent considerable effort in educating the public on sludge constituents, both beneficial and detrimental, to crops.

One critical feature of the public relations program was a detailed knowledge of sludge composition. To describe the positive and negative aspects of sludge application on cropland, it was essential to have detailed chemical analysis of the lagooned sludges. Based on this data, it was possible to state the exact rates of sludge application and explain why these rates were chosen.

It was also the position of the sludge spreading subcontractor that a nominal charge should be assessed per hectare for sludge application. The rationale for this was that, if sludge truly has value in crop production, then a firm would not give it away free-of-charge but would charge at least a portion of the value obtained by the farmer. An additional important factor is that each farmer did not have to purchase additional equipment for applying sludge. The contractor not only applied the sludge but he also applied any agricultural limestone needed to adjust the soil to pH 6.5. All soil sampling and analysis was conducted by the contractor at no charge to the farmer. After sludge application, the contractor incorporated the sludge into the soil surface by disking. The approach used by the contractor did not place any additional workload on the farmers, and this undoubtedly enhanced acceptance of the sludge utilization project by the farmers.

The general contractor and others associated with the project continued to seek good public relations through the various avenues available to them. Examples of this effort included the following:

a. General contractor and City personnel made themselves readily available to the media. One television station produced a series of favorable reports on the project despite start-up problems that included showering commentator and cameraman with sludge in one instance.

b. A construction magazine published a detailed technical description of the project and the equipment used (58).

c. The general contractor made a professionally prepared, twenty minute, color movie of the project available for viewing by a broad spectrum of technical and public interest groups.

A public information deficiency associated with the construction of the second interim (south) sludge lagoon resulted in project delays and costs culminating with the court hearing of August 31, 1977.

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SECTION 7

SLUDGE REMOVAL, TRANSPORTATION AND APPLICATION

SEMI-LIQUID SLUDGE DISPOSAL

Removal of Semi-Liquid Sludge From Lagoons

Removal of sludge from lagoons is not a simple task. The material is frequently stratified in the lagoons with concentrations ranging from nominally clear liquid at the surface to greater than 20 percent solids near the sludge-soil interface at the lagoon bottom. Various methods have been used on other projects to remove sludge from lagoons, including use of dredges. As will be shown later, the wide range of sludge concentrations created problems in selecting the appropriate handling process.

The contractor had developed a procedure for removing sludge from lagoons in a previous sludge relocation contract at the City's Southport Wastewater Treatment Plant. The Southport project required that the contractor move sludge from several existing lagoons to others on the same site. It did not require off-site sludge disposal. Nevertheless, the contractor was able to use the Southport project to evaluate various methods of removing sludge from lagoons and to develop site-specific procedures and equipment.

The contractor's removal method commenced with agitation of the lagoon contents by means of a pontoon mounted device. The location of the floating "agitator" on the surface of the lagoon was controlled by cables connected to a double drum electric hoist. The time required to homogenize the 34,065 to 37,850 cubic meters (9 million to 10 million gallons) of sludge in a lagoon was determined empirically but normally required a minimum of 24 hours.

The winches used to control the floating agitator were mounted on a structural steel framework which also served as a pump station for removal of the homogenized sludge. Two 3.78 cubic meters/min (1,000 gal/min) submersible pumps were suspended from the framework and removed the sludge as it flowed to the pump station. Flow of sludge to the pump station was directed by means of a pontoon mounted "skimmer" which was operated in a similar manner as the agitator. The skimmer was used to maintain a comparatively even rate of sludge flow across the lagoon surface. The sludge was pumped through a 30 cm. (12 inch) diameter, quick coupling, aluminum piping system from the existing lagoons to a 1665.40 cubic meter (440,000 gallon) holding pond. The holding pond, which was lined with 5 cm. (2 inches) of Gunite, served as an equalization basin between the sludge lagoon pump system and the truck loading pumps. It was not necessary to agitate the contents of the holding pond to maintain solids in suspension because of the short detention time in the pond.

The station for loading the sludge hauling trucks was similar to a bulk fuel loading facility at an oil refinery. Each of four 4.2 cubic meters/min (1,100 gal/min) submersible pumps discharged to one of four loading bays. Each bay was capable of pumping 21 cubic meters (5,500 gallons) into the semi-trailer tanker trucks in five minutes.

Transportation of Semi-Liquid Sludge

Sludge was hauled from the Belmont site to Boone Bounty with 29.5 cubic meter (7,800 gallons) semi-trailers attached to conventional highway tractors. The twenty semi-trailers were specially designed and constructed for the sludge hauling operation. The contractor indicated that the twenty semi-trailers contained special provisions for rapid sludge discharge and special materials of construction. The trailers were loaded at less than their nominal capacity because of state highway load restrictions.

A twenty hour per day hauling and spreading schedule was projected, divided into 2 ten-hour shifts per day. Up to 3,785 cubic meters (one million gallons) of sludge per day were transported by the sludge haulers. The trucks were dispatched to the spreading sites or to one of the interim sludge lagoons, if landspreading was not possible at the time. Spreading was halted at times for reasons that included:

a. Sites approved by the regulatory agencies were not always available.

b. Soils at the spreading site were wet or frozen.

c. The period of time between planting and harvesting was too short.

d. Spreading equipment was not always operational.

Hauling from the Belmont site to Boone County was hampered and sometimes halted by a number of factors that included the following:

a. Excess load limits on Boone County roads during the spring thaw period.

b. Vandalism of trucks.

c. Harrassment of drivers by shooting at and sideswiping of the trucks.

However, the transport of the sludge was generally a smooth operation that presented a minimum of problems to the general contractor.

Application of Semi-Liquid Sludge

Spreading of sludge on agricultural land in Boone County, Indiana, was carried out in the four year period of 1977 through 1980. The spreading methods and equipment used varied over this period. Therefore each year will be described separately below. Detailed specifications of the major sludge spreading units are included in Appendix H.

Spreading operations of 1977

Start of spreading operation on September 22, 1977, was comparatively smooth. Sludge was transferred from the transport semi-trailers to the field spreading units by means of an electrically driven 3.78 cubic meters/min (1,000 gpm) centrifugal pump. Power for the pump was provided by a mobile diesel generator. The basic field spreading units for broadcasting sludge on the soil surface were six BetterBilt, 12 cubic meters (3150 gallon) capacity units mounted on four, high flotation tires. The field spreading units were pulled by Ford 9700 farm type tractors. Two 7.6 cubic meter (2000 gallon) GMC Field Gymmys equipped with high flotation tires and rear mounted, shank injectors were used when sludge injection was required. Sludge injection was required in a zone ranging from 15.24 m (50 feet) to 91.44 m (300 feet) from streams, creeks, roads, ponds, and lakes. No sludge was to be applied within 91.44 m (300 feet) of water supply wells, springs, and inhabited residences.

At the peak of the operation, in the fall of 1977, the operation was continued 24 hours per day, six days per week, resulting in approximately 3,785 cubic meters (one million gallons) per day of sludge being removed from the Belmont site. Aproximately 62,360 cubic meters (16.3 million gallons) of sludge were spread on the land and 61,600 cubic meters (16.1 million gallons) were hauled to the Boone County Storage lagoons before unfavorable weather terminated operations for 1977.

Spreading operations of 1978

A wet, late spring delayed the start of landspreading in Boone County in 1978. Approximately 4,975 cubic meters (1.3 million gallons) were hauled from the Belmont site for spreading during the period June 2, 1978, through June 13, 1978. The procedures and equipment used were similar to those used in the Fall of 1977, except that two Terra-Gator 2505 units were substituted for the Field Gymmys used in 1977.

Resolution of a nine week zoning problem associated with the interim sludge lagoons enabled the commencement of sludge hauling from the Belmont site to the Boone County interim storage facilities. A total of 53,438 cubic meters (14.1 million gallons) were hauled in the period August 10, 1978, through September 23, 1978.

Completion of harvesting by a number of farmers enabled the resumption of sludge application in late September 1978. A total of 64,805 cubic meters (17.1 million gallons) were hauled and spread in the period

September 25, 1978, through November 11, 1978, when winter weather terminated operations. A small amount 9,035 cubic meters (2.4 million gallons) was hauled to the interim lagoons, when site conditions precluded landscaping.

Spreading operations of 1979

Approximately 10,700 cubic meters (2.8 million gallons) of semi-liquid sludge were hauled from the Belmont site to the Boone County interim holding lagoon during the period of March 21, 1979, through April 14, 1979. This represented the last of the semi-liquid sludge that was hauled to Boone County from the Belmont site. No sludge was spread during the first half of 1979 due to a late, wet spring.

Approximately 55,000 cubic meters (72,000 cubic yards) of sludge from the Boone County South lagoon was spread in the period October 5, 1979, through December 10, 1979. This period marked the use of new sludge spreading equipment by the project. At one time, two Terra-Gator 2505s, one Big A 4500, and two Field Gymmys were in operation hauling directly from the South lagoon. The Terra-Gator 2505 unit was equipped with five high flotation tires capable of transporting 14.38 cubic meters (3800 gallons) in a pressure/vacuum tank. The Big A 4500 unit was equipped with four high flotation tires and was capable of transporting 13.25 cubic meters (35,300 gallons) in a pressure/vacuum tank.

Spreading operations in 1980

A late winter precluded sludge spreading in the Spring of 1980. However, the contractor carried out a vigorous program in the Fall of 1980 to satisfy the requirements of a one year extension of the August 31, 1977, agreement with the Boone County residents.

The spreading operations were based on high capacity equipment and on techniques proven in past years. Approximately 125,000 cubic meters (164,000 cubic yards) of sludge was spread from both the North and South lagoons in the period October 11, 1980, through November 10, 1980. A large fleet of equipment was assigned to the task including up to four Terra-Gator 2505s, 2 Big A 4500s, 7 semi-trailer type tankers, as well as support equipment. The spreading and lagoon site restoration program was completed by the December 3, 1980, deadline.

Operation Control Procedures

The farm management firm informed the spreading subcontractor of the fields that were available for sludge application and provided a schedule of the order in which the fields were to be spread. The firm also coordinated lime application on fields where prior soil analysis showed pH's less than 6.5. All of the fields were staked to designate the areas where no sludge was to be spread, and the areas for injection or broadcast application of sludge. The fields were then placed on a schedule for spreading operations.

Dispatching

The sludge spreading subcontractor used an OHAUS (Model No. 6010-PC) Moisture Balance to determine the percent total solids of representative sludge samples transported from the Belmont site to Boone County. Because more than 99 percent of the cadmium in the sludge was associated with the solids, careful monitoring of the percent total solids was needed to accurately determine the amount of cadmium applied to the soil. The cadmium application rate was limited to 1.12 kg/ha (1.0 lb/acre) initially and adjusted upward to 2.1 kg/ha later in the project. Figure 3 illustrates the relationship between percent total sludge solids and the sludge application rate calculated for one lagoon. This relationship was determined for the sludge in each lagoon.

A sludge sample was tested at the beginning of every shift for percent total solids. This total solids analysis took approximately one hour to complete; therefore, the rate of application of the previous shift was used until the results of the new solids analysis enabled determination of a new application rate. Normally, four total solids analyses were performed per shift, thereby insuring consistent monitoring of sludge solids concentrations and the associated rates of sludge application. Percent solids, to the nearest 0.1%, was used to calculate the application rate in cubic meters/ha (gallons/acre). In general, the sludge application rate was not changed if the last solids analysis was within 0.1 to 0.5% solids of the previous value.

The spreading contractor maintained records of the total number of tanker loads delivered to a field and the rate of sludge application (see Form A of Appendix F). Each time the rate of application or the field of application was changed, a new Form A sheet was started.

Receiving

All tankers were received at the application site by a representative of the spreading subcontractor who recorded the tanker's time of arrival and signed the trip ticket. After the tankers had delivered their loads, they returned to the Belmont site with three copies of the trip ticket. The general contractor, the spreading subcontractor, and the hauling contractor each received one of the three remaining copies of the trip ticket.

Spreading

Sludge was spread using the subcontractor's personnel and equipment. Records were maintained of tanker loads received, application unit dispatched, the sludge application field and rate of sludge application (see Form B of Appendix F). Each time the rate of application or the field of application was changed, a new Form B sheet was started.

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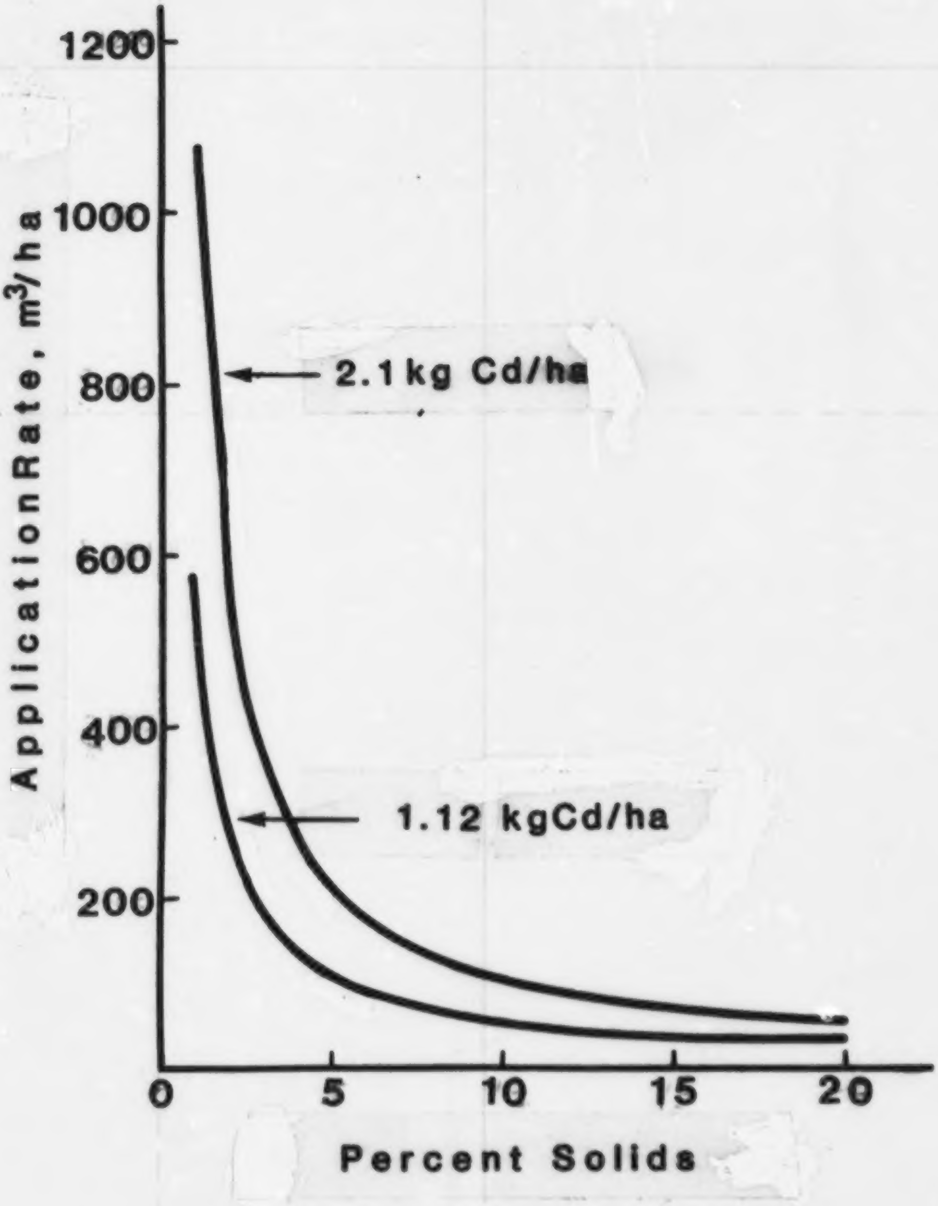

Figure 3. Relationship between percent solids in sludge and application rate based on 1.1 and 2.1 kg Cd/ha.

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Separate Form B sheets were maintained for tanker loads delivered to the interim sludge lagoons.

Disking

The date that the applied sludge was disked-in was provided by the farm management firm to the spreading subcontractor to complete the record of sludge application on a specific field (see Form B of Appendix F). The recording of the date of disking and the forwarding of that record to the general contractor completed the sludge application and the monitoring responsibilities of the spreading contractor.

Recording

Recording and consolidating of operational reports was performed at the Belmont site by the spreading subcontractor. Daily records were consolidated into weekly records which, in turn, were consolidated into monthly records. (See Form C, D and E of Appendix F). Monthly summary sheets were forwarded to the general contractor to support claims for monthly progress payments.

Additional information concerning control procedures is outlined in Appendix C.

DISPOSAL OF OTHER SLUDGES

Ash Disposal

Ash from years of sludge combustion in the Belmont Wastewater Treatment Plant's multiple hearth incinerators represented the majority of contents in lagoons 1 and 2 at the Belmont site (Figure 1). This material was loaded into tri-axle dump trucks with a crane and a 1.15 cubic meter (1.5 cubic yard) drag line bucket and deposited on a portion of the Belmont plant site north of the existing treatment facility at a unit price of \$1.97/cubic meter (\$2.58/cubic yard). The ash disposal site was shaped to a prescribed grading plan and seeded.

Semi-Solid Sludge Disposal

Lagoons 1 and 2 of the Belmont site also included layers of concentrated sludge which were capable of supporting the weight of heavy construction equipment. A residue of semi-solid, "heavy sludge" (generally with a sludge concentration in excess of 20% total solids) remained in the other lagoons after they had been drawn down by the semi-liquid sludge handling procedures described previously. The concentrated sludge of lagoons 1 and 2 and the heavy sludge could not be handled using the procedures developed by the contractor for semi-liquid sludge.

The contractor identified an abandoned landfill situated near the Belmont site as a potential disposal site for the semi-solid, heavy sludge material. The landfill site had been utilized for over sixty years as a refuse landfill and for the immediate past twenty years as a demolition debris disposal area. The building debris was exposed above ground level and served as the primary fuel for an underground fire which broke out at the site in November, 1976. Prolonged and vigorous efforts by the landfill operator to extinguish the fire, which represented a health and safety hazard to a large portion of the south side of Marion County, had failed.

The landfill operator proposed in September, 1977 to the Indiana Stream Pollution Control Board (SPCB), that the concentrated sludge from the Belmont site be used in conjunction with other materials to cover the landfill site in an effort to eliminate the landfill fire as an environmental hazard and public nuisance. The building debris site was to be levelled and a fly ash-lime sludge base spread over the site. A subsequent sewage treatment plant sludge layer was to be placed over the fly ash-lime sludge layer, both for the purpose of smothering the underground fires which remained and serving as the base for a subsequent layer of soil that was to be provided to finish the site. The sludge from the Belmont lagoons 1 and 2 was disposed of in the manner described upon receipt of SPCB approval.

The concentrated sludge of lagoons 1 and 2 was insufficient to cover the entire landfill site. Therefore, the landfill operator sought SPCB approval to utilize the semi-solid, heavy sludge remaining in Belmont lagoons 3, 4, 7, 8, 9, and 10 in a similar manner to lagoons 1 and 2. Semi-solid sludge was subsequently hauled from lagoons 4, 5, 8, 9 and 10 based on the City's review of SPCB documents that appeared to permit the landfill operator to accept the sludge at the landfill. Semi-solid sludge disposal was interrupted by the January 29, 1979 SPCB letter which stopped all sludge disposal at the landfill. Subsequent to that action, hauling of the semi-solid sludge from lagoon 3 was allowed but not that of lagoon 7. The contents of lagoon 7 remained on site in a newly constructed holding lagoon.

Previous correspondence had led the City to believe that the regulatory agencies position was that no further environmental review was required when a State approved landfill was utilized for sludge disposal. SPCB concern regarding the environmental consequences of sludge placed in the landfill caused discontinuation of progress payments under the US Environmental Protection Agency (EPA) Construction Grant Program.

The City subsequently had a comprehensive Environmental Impact Assessment prepared that addressed landfill disposal of the semi-solid sludge The Assessment concluded that the deposited sludge would not have a significant negative effect on the environment and that the sludge remaining on site and that the contents of lagoon 7 still retained on site should be disposed of in a similar manner. A SPCB letter of March 12, 1981 appeared to support the Assessment's conclusion regarding the sludge already deposited in the landfill but rejected the conclusion regarding the sludge remaining on the Belmont site.

Construction Grant funds for landfilled sludge continued to be withheld and sludge from lagoon 7 remained at the Belmont site as of August 15, 1981.

Grease Removal

One part of the project called for removal of a sizable grease lagoon, contaminated with PCB's at a unit price of \$27.41/cubic meters (\$35.86/cubic yard). No approved landfill was available within Indiana to handle the waste containing the high concentration of PCB's in the grease. An approved landfill was located by the contractor in Wayne County, Michigan. The material was loaded into lined semi-trailers and hauled to the disposal site.

SECTION 8

PROJECT OVERVIEW

EXPERIENCE WITH SLUDGE HANDLING EQUIPMENT

Experience gained with the equipment used in this project may be of value to those considering similar projects. It must be noted, however, that the information offered may be specific to this project in many cases.

The equipment and procedures used to remove the sludge from the Belmont site lagoons worked well up to a sludge concentration of 20% total solids. It is impossible, at this time, to determine whether removal of sludge in concentrations greater than 20% could have been achieved by modifications of the system, such as extended periods of agitation or addition of water followed by agitation. The truck loading facility worked well throughout the period of the project.

The semi-trailer tankers used to haul semi-liquid sludge more than 81 km (50 miles)from the Belmont site to Boone County were appropriate for the purpose. Although the special features of their design claimed by the spreading contractor remain proprietary, the units did not manifest problems during their sludge loading-transporting-unloading work cycle. The direct transfer of sludge from a semi-trailer tanker to the applicator vehicle did not pose any problems.

The equipment used for spreading of the semi-liquid sludge on the farmland evolved over the life of the project as described in Section 7. In 1977 and 1978, the basic sludge spreading units were farm tractor-drawn, wheel-mounted units as developed for application of liquid animal wastes. This equipment proved to be too slow in moving over the fields for this scale of a project. The Field Gymmy equipment experienced structural damage when operated across the furrows of plowed fields by drivers unfamiliar with this type of driving condition. Summary specifications of the Field Gymmy and other self-propelled spreading equipment are provided in Appendix H.

A different subcontractor carried out the spreading operations in 1979 and 1980. The subcontractor did not use the farm tractor-drawn applicator units but substituted comparatively high speed, 48.3 km/hr (30 mph), self-propelled, off-road vehicles, designed for applying sludge to soils. This equipment was able to serve both as a spreading unit and as an injection unit. This type of equipment appeared to be more appropriate for the high production operation required for this project.

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RETENTION OF CONSULTING AGRONOMIST

The City identified a need for a person with specialized expertise in the field of sludge disposal on agricultural land. It was felt that this expertise would provide added project credibility with both the general public and the regulatory agencies and additional technical assistance to the project. At the request of the City, the consulting agronomist prepared an evaluation of the agronomic implications of the project. His evaluation was that the project was well designed and incorporated the latest concepts for land application of sludges. The consulting agronomist supported the ISBH requirements for continuous monitoring of the sludge removal and spreading operations. He continued to be associated with the project in a consulting role and was also involved in designing a program for sampling and analyzing the corn and soybean crops raised on sludge-treated fields.

MONITORING OF CROP COMPOSITION

The SPCB required that samples of corn and soybean grain be collected and analyzed the first year after sludge application. Random samples of grain were collected by hand harvesting in September of each year. Samples were collected from both sludge-treated and an adjacent field not treated with sludge. Because the same variety of corn or soybeans was not necessarily grown in adjacent fields, the comparison of cadmium (Cd) and PCB concentrations of crops grown on treated and untreated areas may reflect the influence of both crop variety and sludge application. The data obtained on the cadmium and PCB concentrations in corn and soybeans are presented in Table 7. All crop samples were obtained during the first cropping season after sludge application. In 1978, some corn grain samples showed slightly increased concentrations of cadmium. All subsequent samples of corn and soybean grain contained nondetectable levels of both cadmium and PCB's.

PROBLEMS ASSOCIATED WITH THE PROJECT

Hindsight enables identifying what caused many of the problems associated with the conception and performance of the sludge disposal project. Insight derived from reviewing many of the identified problems are presented in the following paragraphs.

The original sludge sampling and analysis was inadequate in light of subsequent regulatory agency concern for heavy metals and toxic substances in the sludge. A minimal program of sampling and analysis was conducted by the contractor and it failed to properly identify the quantity, range of solid concentrations, and chemical constituents of the lagooned sludge. A critical sludge constituent, PCB's, was not determined during the original sludge sampling and analysis and it subsequently inhibited the contractor's activities. The original sludge data may have led the contractor to underestimate both the quality and quantity of sludge contained in the lagoons.

TABLE 7. CONCENTRATIONS OF CADMIUM AND PCB's IN CORN AND SOYBEAN GRAIN GROWN ON SLUDGE-TREATED AND UNTREATED SOILS IN BOONE COUNTY

Year	Crop	PCB in grain		Cd in grain	
		Sludge-treated	Untreated	Sludge-treated	Untreated
		µg/kg			
1978	Corn (9)	<1	<1	100	<20
	Soybeans (6)	<1	1	60	<50
1979	Corn (9)	<1	<1	<50	<50
1980	Corn (12)	<1	<1	<50	<50

[a] Number in parenthesis indicates the total number of samples analyzed.

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A more comprehensive sludge sampling and analytical program was required by the regulatory agencies after bids had been opened. Collection of samples was facilitated by a thick ice layer (~30 cm) that covered the lagoons during the sampling period. The identification of PCB concentrations in two lagoons considered too high for land application further dislocated the contractor's planning efforts. The final, detailed sampling and analyses performed after bids were opened have proved to be accurate in view of the total amount of sludge solids measured during emptying the lagoons.

Additional problems were caused by the general nature of the bid package (Appendix A).

The bid package permitted a choice of sludge disposal methods, including: 1) Chemical Fixation Processes; 2) Chemical Conditioning, Dewatering and On-Site Disposal; 3) Land Application and; 4) Other Disposal Techniques. Although each option was required to satisfy a basic requirement - to be "environmentally acceptable" - the options were hardly comparable on an "apples-to-apples" basis. The decision to allow alternative sludge disposal processes was a result of the "and/or equal requirements" of the US EPA Construction Grant Program. However, considering the emotional, technical, and political sensitivity of municipal sewage sludge disposal, the City should have either specified only a single sludge disposal method or conducted a more intensive planning effort to develop detailed specifications for each disposal option.

The specifications attempted to assign all responsibility and liability associated with sludge disposal to the contractor but both State and US EPA regulations did not permit the City to divorce itself from responsibility for off-site sludge disposal.

The necessity for sufficient interim off-site sludge storage was not fully recognized and required a "crash" effort to provide more sludge storage in the vicinity of the sludge application sites. Storage volumes equal to the volume of the lagoons which were to be emptied should have been provided. The rate of sludge removal was inhibited by the maximum rate of land spreading, the volume of off-site interim sludge lagoons, and highway load restrictions.

Recognition of the need for additional off-site sludge holding capacity, after bids were accepted, resulted in the only citizen opposition to the project. The spreading of sludge on agricultural land appeared to be universally accepted in Boone County as a beneficial activity. Much of this acceptance may well have been a result of a vigorous public relations program. However, the construction of an interim sludge lagoon, with little public information, aroused an almost hysterical reaction causing legal action which delayed the project.

Use of an interim sludge lagoon presents other problems such as zoning. Holding sludge in the interim lagoon for ultimate sale and spreading on land under ownership other than that on which the lagoon is built, implies that the property is now being used for storage of a

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salable commodity and may require rezoning from agricultural use. While rezoning is not an insurmountable task, it does take time and leaves the project open to additional exposure and organized oppositions.

The bid documents and the contractor did not place sufficient importance on the very short period of time actually available to spread sludge on land that is being used for growth of row crops by individual farmers. Indiana State Board of Health regulations would not permit sludge spreading on frozen ground. From a practical standpoint, sludge could not be spread after planting and before harvesting the crop. The contractor was therefore restricted to two short periods of time for sludge application; after the soils thawed and before spring planting, and after harvesting and before the soils froze.

The high level of monitoring and record keeping was not initially recognized by the contractor or City. It was finally appreciated that continuous field inspections by the design engineer's personnel would be required to assure that the maximum sludge application rates were not exceeded. A massive array of documentation was required of the program ranging from the initial signed release form of the land owner to the final chemical analysis of the harvested crop from the land. The time and cost of preparing and maintaining the required level of documentation has been a significant burden on the project. It now appears that some of the records will have to be maintained in perpetuity. The time, effort, and cost of the monitoring program associated with this type of project is considerable and must be recognized.

The contractor attempting this type of project must have a number of specialized skills including those of heavy construction, materials transport, and crop production. An equally important skill is an understanding of and experience in dealing with regulatory agencies. The contractor had difficulty in dealing with bureaucracies. Statements made by the spreading subcontractor in the environmental assessment document unnecessarily restricted the rate of sludge application. Obtaining relief from these self-induced restrictions required a great deal of subsequent time and effort.

The equipment selected and used by the contractor was inadequate for land disposal of heavy, "bottom" sludges with concentrations in excess of 20 percent solids. The contractor set up an expensive and overall efficient system to handle sludges with concentrations less than 20 percent total solids but the pumping, hauling, and spreading equipment was generally unable to handle sludges in excess of 20 percent. It can only be speculated whether, the contractor would have selected other equipment if the large quantity of "heavy" sludge had been identified.

It is doubtful whether the contractor or others associated with the Project properly recognized the specialized skills and experience required for such an effort. The spreading subcontractor, though well able to relate to the agricultural industry, could not develop the organization to satisfy the high rates of activity necessary to meet the project schedule. The general contractor was required to reorganize and supervise the

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spreading subcontractor's activities to maintain the schedule.

Standard agricultural quality equipment was unable to meet the demands of maintaining high utilization rates on a round-the-clock basis. This problem was intensified by the use of union equipment personnel to operate the spreading equipment. This type of operator, who had no familiarity with the specific procedures or equipment, increased the stress on the machinery. It was recognized, by the end of the first spreading season, that heavier, faster, construction grade equipment was necessary in place of the lighter, slower, agricultural grade equipment that had been used in the first season.

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APPENDIX A

BID DOCUMENT: SLUDGE, CONTAMINATED MATERIALS, NON-CONTAMINATED SOILS GREASE AND ASH DISPOSAL[a]

PART 1 - GENERAL

1.01 DESCRIPTION

A. Work under this section includes but is not limited to the following:

1. Treatment and disposal of sludge, contaminated soils, non-contaminated soils, grease and ash.

B. Related work specified elsewhere includes but is not limited to the following:

1. Sitework - Section 02000
2. Excavation, Trenching and Backfilling - Section 02221
3. Mass Excavation and Engineered Fill - Section 02222
4. Bentonite Clay Lining - Section 02244
5. 120" Effluent Pipe - Section 15063

1.02 DEFINITIONS OF MATERIALS

A. Sludge - Dark organic and inorganic material in combination with water located in Lagoons No. 1 through 18, excluding the ash in Lagoons No. 1 and 2.

B. Grease - A group of substances including fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and certain other nonfatty materials located in the grease pit shown.

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[a] Copy of original bid document modified where necessary to incorporate subsequent addenda. All sections added to the original bid document are enclosed in brackets.

C. Contaminated Soil - The eighteen (18) inches of soil immediately adjacent to and in contact with the sludge in the bottom and sides of a sludge lagoon and any soils that by visual inspection of the Project Engineer are seen to be mixed with grit, grease, sludge, or other organic wastes.

D. Unsuitable Soils include, but are not limited to, the following:

1. All soil containing more than five (5) percent organic matter by weight.

2. All soil containing rubble, debris, wood, paper, metal, grease, or other man-made objects.

3. Any granular soil material with a relative density less than 70 percent.

4. Any cohesive soil with shear strength and compressibility characteristics which will result in either bearing capacity failure or excessive settlement of foundations when used for fill or sub-grade for the proposed facilities.

E. Ash - The residue left from the products of combustion resulting from the incineration of sludge. The ash is located in Lagoons No. 1 and No. 2.

F. Non-contaminated Soil - Any soil other than soil defined as contaminated soil herein.

1.03 GENERAL REQUIREMENTS FOR ALL WORK UNDER THIS SECTION

A. Contractor shall plug and abandon or remove all overflows and drains from existing lagoons as shown.

B. Contractor shall install drains, sewers and inlets necessary to collect all runoff and leachate from all disposal areas constructed at the Belmont Wastewater Treatment Plant and as shown.

C. All disposal areas constructed at the Belmont Wastewater Treatment Plant except for ash and non-contaminated soil disposal sites, shall be sloped and drained during construction and all runoff collected and disposed of at the Belmont Wastewater Treatment Plant. Contractor shall provide all piping and equipment necessary to transport all such run-off during construction. The run-off shall be transported to the wastewater treatment plant as directed by the Project Engineer. All runoff and drainage collected and transported to the wastewater treatment plant, with the exception of the filtrate from Option No. 2, will be treated without additional charge to the Contractor.

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D. Methods of disposal and transportation of all materials shall have the approval or concurrence of all agencies having jurisdiction.

E. Contractor shall prevent any sludge, contaminated material or leachate from entering or spilling into any body of water, any aquifer, or onto any lawn or pavement, and shall maintain the integrity of all adjacent sludge lagoons that are not being emptied.

F. "Approved Landfills" shall be defined as landfill sites that have the written approval of all agencies having jurisdiction for the disposal of the specific material proposed to be disposed of therein.

[G. The Contractor shall provide within forty-five (45) consecutive calendar days after Tentative Award of the Contract, a release from each landowner, tenant and any other party having an interest in said land or crops of said land, where an off-site disposal area is to be located in the following form; subject to such additions as may be approved by the Owner to explain the use of the sludge or waste material, and which will not impair the legal effects of the release:

RELEASE

The undersigned (party) (Parties)* having an interest, as indicated below, in property, or crops on said property, upon which sludge or waste materials removed from the Belmont Treatment Plant of the City of Indianapolis is to be (applied), (stored) (or disposed of),* acknowledge(s) that results of testing of the material being stored) (applied) (or disposed of)* made by____
(Name of Testing Entity)
have been made available to them, but that it is impossible to know the exact contents of all the material or the possible effects of the material and its contents upon land, personal property, crops, animals or human beings.

In consideration of being permitted to (purchase) (or acquire)* said sludge or waste materials from
____, the
(Name of Contractor or Subcontractor)
undersigned (does) (do)* hereby release the City of Indianapolis, its Project Engineer, the Project Engineer's Consultants, and their agents and employees from and against all claims, damages, losses and expenses including attorneys' fees arising out of or resulting from the (storage) (application of) (or disposal)* of such materials, including claims based upon the negligence of the released party.

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Interest in Property and/or Crops

*Strike Inapplicable Words]

H. Disposal sites, except those for ash and non-contaminated soils, constructed on the site of the Belmont Wastewater Treatment Plant shall have bentonite clay liners installed as specified in Section 02244 and sloped to drain to points shown and specified.

I. Where ash is disposed of at the Belmont North Disposal Site no bentonite clay liner will be required. The ash shall be covered with one foot of soil suitable for growing grass, mulched seeded and sloped to drain to the southeast of the site. The Contractor shall control erosion of the covered area until the grass cover is established. Contractor shall maintain the area until time of acceptance by the Owner. Ditches and storm sewers shall be constructed to handle run-off equal to a two-year one-hour storm intensity of 1.25 inches. The storm sewer shall cross under the road and drain to approximate coordinates 5344N/2264E. Contractor shall submit plans, including calculations to the Project Engineer for review. These plans shall include grading and drainage system plans and shall be prepared by and under the seal of a professional engineer registered in the State of Indiana.

J. All ash disposed of off-site shall be disposed of in a landfill approved for this material and conforming to the requirements of paragraph 1.02F. above.

K. Non-contaminated soil may be used, if suitable, for fill materials in the Work. Portions of such materials that are unsuitable for fill or in excess of that needed for fill shall be deposited on-site in areas directed by the Project Engineer.

L. The Contractor's attention is called to the fact that the Belmont North Disposal Site referred to in these Contract Documents is on top of a previously covered garbage landfill. No borrow material shall be obtained from and no excavation shall be performed in this area except for the excavation required for the construction of the drainage facilities.

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[M. Contaminated materials as defined may be found within the Central Site Limits and within the South Disposal Site Limits shown and at the interface of the ash or sludge and the bottoms of Lagoons No. 1 through No. 18 as well as the interface of the grease and the bottom of the grease pit. Contaminated materials may be disposed of in any of Lagoons No. 11 through 18 that have been dewatered and lined with a bentonite/clay liner if space is available.]

N. Materials removed from Lagoons 11 through 18 may be returned to these same lagoons after these lagoons have been lined as specified herein.

[O. All sludge, ash, and contamined materials not disposed of on-site and all grease shall be disposed of only at "approved" landfills.]

[P. The Owner will treat any filtrate, supernatant, subnatant or other waste flow resulting from any process the Contractor uses in treating the sludge or other materials subject to the following rates and restrictions:

a. Formula for determining treatment costs for all waste flows that are treated in the Owner's treatment plant:

$$S = V_s \text{ x } 8.34 \quad \$0.017\text{x}(BOD) + \$0.0244\ (SS))$$

Where:

S = Is the charge in dollars

V_s = Is the sewage volume in million gallons

8.34 = Converts parts per million to pounds per gallon

$0.017 = Is the charge for BOD in dollars per pound

BOD = Is the BOD_5 (biological oxygen demand) in parts per million by weight

$0.02244 = Is the change for suspended solids in dollars per pound

SS = Is the suspended solids in parts per million by weight]

b. The Contractor shall use no chemicals in his process that will result in a waste flow chemical content that will cause deterioration of the effluent quality of the wastewater treatment plant.

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c. The Contractor shall provide all necessary piping and equipment required to transport the waste flow to the inlet of the aeration tanks as directed by the Project Engineer.

d. The daily average suspended solids concentration in the waste flow shall be 2,000 milligrams per liter or less and at no time shall the waste flow contain more than 3,000 milligrams per liter suspended solids. The maximum quantity of solids directed to the Owner's aeration tanks shall not exceed two (2) tons of dry solids per day.

e. The weekly average BOD concentration in the waste flow shall be 2500 milligrams per liter or less and at no time shall the waste flow contain more than 3,000 milligrams per liter BOD.

f. The Contractor shall collect samples of the waste flow at the point where the waste flow enters the treatment plant and shall provide total suspended solids and BOD data on such samples to the Project Engineer. One sample shall be taken every four hours, or fraction thereof, of operation of the processing equipment and composited with other samples taken during each (8) hour shift. A total suspended solids analysis shall be conducted on the composite sample from each shift and a daily BOD analysis shall be conducted on another composite sample made from all samples taken in a day by a laboratory approved by the Owner and according to "Standard Methods for the Examination of Water and Wastewater" (APHA, AWWA, and WPCF). This data shall be provided the Project Engineer on a weekly basis and shall be available for inspection upon request of the Project Engineer.

g. No dilution water may be added to waste flows to reduce suspended solids or BOD concentrations.]

Q. Contractor shall execute the mixing, removal, transport, and treatment of all sludge in a manner to minimize the release of odors into the atmosphere. Contractor shall also conduct all work relative to the mixing, removal, transportation and treatment of the sludge in conformance with the requirements of all agencies having jurisdiction. Contractor shall be responsible for providing all necessary scrubbing, filtering, masking, or other methods of odor control required in the prosecution of his work by the foregoing agencies. In the event the air pollution requirements of all agencies having jurisdiction are not met, all work affected by said regulations shall be halted immediately and necessary action shall be taken to cause such work to conform to said requirements prior to re-commencing such operations.

R. All sludge and contamined materials removed from the Work Site shall become the property of and the sole responsibility of the Contractor.

[S. The Owner will make progress payments for sludge or other materials taken off-site and temporarily lagooned or stored prior to final disposal subject to the retainage requirements of Section 01370, Schedule of Values, but not to exceed the actual costs incurred by such lagooning or storing or the costs for this work set forth in the Schedule of Values.]

[T. Sludge, ash, and grease from Lagoons 1 through 10 shall be removed and treated as required by the specific option. The sludge from Lagoons 12 and 16 shall be removed to allow construction of the 120" effluent line. This sludge may be temporarily stored in any lagoon that has been emptied for construction. After the construction and sealing of this line, and the construction of a bentonite/clay liner in Lagoons 12 and 16, as specified, such sludge may be replaced in Lagoons 12 and 16. The contractor does not have to treat the sludge that he removes from, and replaces in Lagoons 12 and 16 unless he desires to do so as part of his treatment and disposal of sludge removed from the central site limits.]

[U. The Contractor shall provide a plan with his bid showing how he proposes to dispose of any materials at the Belmont North Disposal Site.]

PART 2 - MATERIAL DISPOSAL OPTIONS

2.01 Option No. 1 - Chemical Fixation Processes

A. Chemical Fixation is one on-site method for the disposal of the sludges removed from lagoons 1 through 10 at the Belmont Wastewater Treatment Plant No. 1.

[B. If chemical fixation is used, the sludge shall be disposed of at the Belmont North Disposal Site. Grease that is removed shall be disposed of off-site in an approved landfill for such material. Ash may be disposed of at the Belmont North Disposal Site or off-site in an approved landfill for such material.]

C. The Belmont North Disposal Site shall be prepared for the installation of the chemically fixed sludge by sloping the bottom to allow drainage to the southeast corner of the disposal site at approximate coordinates 5750N/2350E. A bentonite/clay liner as specified in Section 02244 shall then be installed as specified and a system of leachate underdrains and other facilities, as necessary, shall be installed immediately above the bentonite/clay liner and piped under the road as shown to an existing manhole at approximate coordinates 6280N/2314E. After the chemically fixed sludge has been placed in the area with maximum slopes of 3:1, one foot of clay and six inches of soil suitable for grass cover, shall be installed on top of the chemically fixed sludge. The surface shall be sloped to drain to the southeast corner of the disposal site and necessary catch basins and storm sewers constructed to connect to a storm sewer that shall be installed under the road in order to drain the surface of the North Disposal Site to the area at approximate coordinates 5344W/2264E. The soil shall then be mulched seeded as specified. Contractor shall control all erosion and maintain seeded areas until acceptance by the Owner. Contractor, before placing any chemically fixed sludge on the Belmont North Disposal Site shall submit grading plans, drainage plans, subsurface drainage plans, leachate control scheme and all calculations to the Project Engineer and the Indiana State Board of Health for review. These plans shall be prepared by and under the seal of a professional engineer registered in the State of Indiana. A two year - 1 hour storm intensity of 1.25 inches shall be used in calculations for the surface runoff.

D. Chemical fixation, if used, shall be accomplished by processes, methods and equipment capable of producing a product that has mechanical properties suitable for landfill on top of ground surfaces, capable of being contoured and capable of supporting a bearing pressure of 1,000 PSF. The processed sludge shall also possess leachate properties defined as follows:

1. The chemical characteristics of the leachate listed as maximum levels in milligrams per liter (mg/L) shall be as follows: Cadmium (Cd) 1 mg/l or less. Total chromium (Cr) 1 mg/l or less. Lead (Pb) 1 mg/l or less. Mercury (Hg) 0.1 mg/l or less. Nickel (Ni) 1 mg/l or less. Zinc (Zn) 1 mg/l or less. Copper (Cu) 1 mg/l or less.

2. The chemical characteristics of the leachate shall be determined by standard leachate tests which shall be conducted in the following manner:

    a. One hundred (100) grams of the material to be leached shall be placed in a forty by six-hundred (40 x 600) millimeter chromatography column containing one inch of glass wool at the bottom interface.

    b. The material to be leached shall then be compacted in the column.

    c. Distilled water shall be used as the diluent. The remaining volume of the column above the material to be leached shall be filled with distilled water.

d. Diluent water shall be allowed to seep through the material at a rate of approximately one (1) cubic centimeter of water per minute. The diluent water which seeps through the material is called the "leachate" and shall be collected.

e. The leachate shall be collected in one-hundred (100) cubic centimeter portions.

f. Leachate portions or various composite portions shall be analyzed by Atomic Absorption, Spectrographic, Colorimetric or wet methods (as required) to determine the concentration of any constituents which were leached from the material under analysis. Results shall be reported in milligrams per liter.

3. Volume increase of the sludge after chemical fixation shall be limited to a maximum of 10 percent.

E. Timing of the Work to be performed under these Contract Documents is critical to the completion of the Advanced Wastewater Treatment Project at the Belmont Wastewater Treatment Plant No. 1. Obtaining the required approvals or concurrences to dispose of the sludge or other materials as proposed may be delayed by the nature of the remonstrance and other response to the hearing(s), if any, as well as by other unforeseen legal or technical considerations. If delays in obtaining the necessary approvals or concurrences for the proposed disposal method for the sludge or other material extend later than ninety (90) consecutive calendar days from the Tentative Award of the Contract, the Owner may deem the bid non-responsive and award the Contract to another bidder.

F. Contractor using this option shall provide, at Project Close-out, Certificates of Insurance that will provide $10,000,000 Excess Indemnity Limits covering the following for a period of two (2) years after Project Close-out:

1. Stability of chemically fixed sludge.

2. All off-site disposal of materials.

3. All off-site stored materials.

4. All off-site transportation and operations.

2.02 OPTION NO. 2 - CHEMICAL CONDITIONING, DEWATERING AND ON-SITE DISPOSAL

A. Chemical conditioning and dewatering of the sludges in lagoons 1 through 18 and then storing the dewatered sludge in lagoons 11 through 18 is another method of removing the sludge from lagoons 1 through 10. If this method is used, the resulting

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dry cake, after dewatering, shall have a minimum of 25% solids by weight and shall have a volume no greater than one-half the sludge's original volume.

[B. If the chemical conditioning, dewatering and on-site disposal method is used, the lagoons dewatered in the South Disposal Site Limits for use in disposal of sludge shall be lined with a bentonite/clay liner as specified in Section 02244. All of the ash shall be disposed of at the Belmont North Disposal Site as specified in paragraph 1.02I above or at an approved landfill. The grease shall be disposed of off-site in an approved landfill. Contaminated materials shall be disposed of in Lagoons No. 11 and 18 at the Belmont Wastewater Treatment Plant if sufficient volume is available after deposition of the chemically conditioned, dewatered sludge.]

C. Excess sludge, ash, grease or other contaminated materials shall be disposed of only at "approved" landfills.

D. Timing of the Work to be performed under these Contract Documents is critical to the completion of the Advanced Wastewater Treatment Project at the Belmont Wastewater Treatment Plant No. 1. Obtaining the required approvals or concurrences to dispose of the sludge or other materials as proposed may be delayed by the nature of the remonstrance and other response to the hearing(s) if any, as well as by other unforeseen legal or technical considerations. If delays in obtaining the necessary approvals or concurrences for the proposed disposal method for the sludge or other materials extend later than ninety (90) consecutive calendar days from the Tentative Award of the Contract, the Owner may deem the bid non-responsive and award the Contract to another bidder.

E. The Contractor using this option shall provide, at Project Close-out, Certificates of Insurance that will provide $10,000,000 Excess Indemnity Limits covering the following for a period of two (2) years after Project Close-out:

1. All off-site disposal of materials.
2. All off-site stored materials.
3. All off-site transportation and operation.

2.03 OPTION NO. 3 - LAND APPLICATION

A. This method offers the option of off-site transportation and disposal of the sludge using land application.

B. All of the information required from the Bidder for obtaining approval or concurrence of this method of sludge disposal from all agencies having jurisdiction with the exception of the public hearing response, if any, shall be submitted with the bid. This information shall be prepared by and under the seal of a professional engineer registered in the State of Indiana and the state of the disposal site if other than Indiana and submitted in the appropriate format to the appropriate agencies having jurisdiction, and the Owner. Bidder shall also provide with his bid a letter signed by an individual having authority to do so (in conformance with paragraph 1.02 of the Instructions to Bidders), warranting that he has procured the adequate land area required for the sludge disposal and sludge storage methods that he proposes using for his method of disposal. The Owner will deem the bid of any bidder who fails to provide this letter as non-responsive.

C. The public hearing(s), if required, for the land application method shall be postponed until after a bidder proposing such a disposal method receives Tentative Award of the Contract. The hearing(s) shall then be held, if required, and all the information obtained from this hearing(s), including the transcript and all remonstrance and other responses, shall be submitted to the Owner and the agencies having jurisdiction (five (5) copies each) within forty-five (45) days after the date of the Tentative Award. The transcripts shall be prepared and certified by a qualified Court Reporter approved by the Owner. All remonstrance or other responses shall be reported to the Owner in writing during the ten (10) consecutive calendar day period following the date of the hearing(s). All remonstrances shall be forwarded in their entirety, if in writing, and thoroughly reported in writing if verbal. All hearing(s), if required, shall be held by the Contractor for the Owner and such hearing(s) shall comply with all requirements of all agencies having jurisdiction. The costs of holding the hearing(s), and the preparation of transcripts and submittals associated with such hearing(s) shall be borne by the Contractor.

D. If all required documentation is not provided the Owner within ten (10) consecutive calendar days following the public hearing(s), the Owner will deem the bid nonresponsive and award the Contract to another bidder.

E. Timing of the Work to be performed under these Contract Documents is critical to the completion of the Advanced Wastewater Treatment Project at the Belmont Wastewater Treatment Plant No. 1. Obtaining the required approvals or concurrences to dispose of the sludge or other materials as proposed may be delayed by the nature of the remonstrance and other response to the hearing(s), if any, as well as by other unforeseen legal or technical considerations. If delays in obtaining the necessary approvals or concurrences for the proposed disposal method for the sludge or other materials extend later than forty-five (45) consecutive calendar days from the time of the Owner's submission of the required documentation to the agencies having jurisdiction, the Owner may deem the bid non-responsive and award the Contract to another bidder.

F. The Owner has not conducted the sampling, testing, and analysis, required to prove the viability and safety of any type of off-site sludge disposal method. The Contractor shall provide all sampling, testing, and analysis, required to prove the viability and safety of the sludge disposal techniques that he proposes.

G. All sludges shall be disposed of in accordance with the requirements of this Article. All ash shall be disposed of at the Belmont North Site, as specified, or in an approved landfill. All grease shall be disposed of in an approved landfill.

H. If Option 3 is selected by the Owner and the Notice of Tentative Award is received by the Bidder, the Bidder shall assist the Owner in consulting with and obtaining approval or concurrence from the appropriate agencies having jurisdiction and with the Owner on the wording of the announcement of Public Hearing(s), Location of the Public Hearing and the requirements for publication and advertising the Hearing(s).

I. The Contractor using this option shall provide, at Project Close-out, Certificates of Insurance that will provide $10,000,000 Excess Indemnity Limits covering the following for a period of two (2) years after Project Close-out:

1. All off-site disposal of materials.
2. All off-site stored materials.
3. All off-site transportation and operations.

2.04 OPTION 4 - OTHER DISPOSAL TECHNIQUES

[A. This method offers the option of using other on-site sludge disposal methods or off-site transportation and sludge disposal methods using any environmentally acceptable method the Bidder proposes.]

B. All of the information required from the Bidder for obtaining approval or concurrence of the proposed method of sludge disposal from all agencies having jurisdiction with the exception of the public hearing response, if any, shall be submitted with the bid. This information shall be prepared by and under the seal of a professional engineer registered in the State of Indiana and the state of the disposal site if other than Indiana and submitted in the appropriate format to the appropriate agencies having jurisdiction, and the Owner. Bidder shall also provide with his bid a letter signed by an individual having authority to do so (in conformance with paragraph 1.02 of the Instructions to Bidders), warranting that he has procured the adequate land area required for the sludge disposal and sludge storage methods that he proposes using for his method of disposal. The Owner will deem the bid of any bidder who fails to provide this letter as non-responsive.

C. The public hearing(s), is required, for the proposed off-site disposal method shall be postponed until after a bidder proposing such a disposal method receives Tentative Award of the Contract. The hearing(s) shall the be held, if required, and all the information obtained from this hearing(s), including the transcript and all remonstrance and other responses, shall be submitted to the Owner and the agencies having jurisdiction (five (5) copies each) within forty-five (45) days after the date of the Tentative Award. The transcripts shall be prepared and certified by a qualified Court Reporter approved by the Owner. All remonstrance or other responses shall be reported to the Owner in writing during the ten (10) consecutive calendar day period following the date of the hearing(s). All remonstrances shall be forwarded in their entirety, if in writing, and thoroughly reported in writing if verbal. All hearing(s), if required, shall be held by the Contractor for the Owner and such hearing(s) shall comply with all requirements of all agencies having jurisdiction. The costs of holding the hearing(s), and the preparation of transcripts and submittals associated with such hearing(s) shall be borne by the Contractor.

D. If all required documentation is not provided the Owner within ten (10) consecutive calendar days following the public hearing(s) the Owner will deem the bid non-responsive and award the Contract to another bidder.

E. Timing of the Work to be performed under these Contract Documents is critical to the completion of the Advanced Wastewater Treatment Project at the Belmont Wastewater Treatment Plant No. 1. Obtaining the required approvals or concurrences to dispose of the sludge or other materials as proposed may be delayed by the nature of the remonstrance and other response to the hearing(s) if any as well as by other unforeseen legal or technical considerations. If delays in obtaining the necessary approvals or concurrences for the proposed disposal method for the sludge or other materials extend later than forty-five (45) consecutive calendar days from the time of the Owner's submission of the required documentation to the agencies having jurisdiction, the Owner may deem the bid non-responsive and award the Contract to another bidder.

F. The Owner has not conducted the sampling, testing, and analysis, required to prove the viability and safety of any type of off-site sludge disposal method. The Contractor shall provide all sampling, testing, and analysis, required to prove the viability and safety of the sludge disposal techniques that he proposes.

[G. All sludges shall be disposed of in accordance with the requirements of this Article. All ash may be disposed of at the Belmont North Site, as specified, or in an approved landfill. All grease shall be disposed of in an approved landfill. The Contractor shall comply with all requirements of all agencies having jurisdiction and shall install a bentonite/clay liner in any on-site area used for disposing of any sludge or contaminated materials.]

H. If Option 4 is selected by the Owner and the Notice of Tentative Award is received by the Bidder, the Bidder shall assist the Owner in consulting with and obtaining approval or concurrence from the appropriate agencies having jurisdiction and with the Owner on the wording of the announcement of Public Hearing(s), location of the Public Hearing(s) and the requirements for publication and advertising the Hearing(s).

I. The Contractor using this option shall provide, at Project Close-out Certificates of Insurance that will provide $10,000,000 Excess Indemnity Limits covering the following for a period of two (2) years after Project Close-out:

1. All off-site disposal of materials.

2. All off-site stored materials.

3. All off-site transportation and operations.

END OF SECTION

APPENDIX B

PUBLIC RELATIONS MATERIAL

PRESS RELEASE A

December 7, 1976

FOR IMMEDIATE RELEASE

Indiana agriculture will benefit from the recycled use of nutrients in sewage sludge in an innovative program described today by J. Fred Duff of Lebanon as a prototype plan meeting environmental needs of the state and nation.

President of Duff Farm Management Services, Inc., which he has operated since 1939, Duff also is president of the Organic Materials Corporation. That company is a tentative sub-contractor in an Indianapolis project involving the removal of almost 100 million gallons of sludge from the Belmont Wastewater Treatment Plant.

Use of the sludge as a fertilizer is a feature of a tentative award granted Monday by the Indianapolis Board of Public Works as part of its $212 million project upgrading the city's wastewater treatment facilities. Affecting the site-preparation phase of the project, the award was given Tousley-Bixler Construction Company of Indianapolis on its bid of $12.1 million. Final approval is subject to concurrence by state and federal governmental authorities.

Duff said Organic's land application plan was given a public demonstration in Boone County on November 25, 1975, and many farmers have been enrolled for the program. "The material will be spread only when the farmer asks for it and he will be buying it because it is a good deal for him," he stated.

"Not only will it reduce costs normally expended by farmers for fertilizer, but the applications will match a chemical analysis of the materials with the crop and soil needs of each farm tract," Duff said. The crop land applications will follow a criteria developed through consultations with agronomists of Purdue University, and the standards "will do more than comply" with over-all environmental and health guidelines, he said.

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The nearly 100 million gallons of seasoned and treated sludge is to be removed from 10 lagoons in which it has been stored for more than 10 years. The lagoons are to be emptied to provide space for construction work modernizing the treatment facilities.

Under the plan, the material will be hauled away in tank trucks and transported to land application sites. There the material, which is made up of five to 10 percent solids, will be sprayed on farm land as weather and crop seasons permit. When inclement weather conditions prevent immediate land application, the sludge will be stored temporarily in a lagoon to be located in Boone County.

Duff said the sludge will be applied on approximately 9,200 acres at a rate of four dry tons per acre, or at a depth of approximately one-third of an inch. They will be sprayed by high flotation vehicles. Primary nutrients applied by Organic will be nitrogen, phosphorus and potassium. The cost will be $22 per acre through 1977, which is compared with a $110 per acre cost for traditional fertilizers with equivalent nutrient content.

Nutrient tables developed by Purdue agronomists will guide Organic and its farmer customers on land applications. The standards relate the sludge's nutrients to various types of soils, various crops and their desired yields, and fertilizer supplements which may be needed.

Duff stressed that odors normally associated with sludge will not be present because odors involve sludge digestion during the early months of storage and the material is more than 10 years old. He described the affected material's odor as a "musty earthy odor."

Duff is a past president of the American Society of Farm Managers and Rural Appraisers, an organization of 2,500 members. He attended Wabash College and Purdue University, and has been active in Indiana agricultural affairs.

Tousley-Bixler said one lagoon contains greases which will require special depositing in a government-approved site not yet determined. Among available sites is one in Illinois, the company said, emphasizing that material will not be part of the land application program.

PRESS RELEASE B

December 28, 1976

FOR IMMEDIATE RELEASE

Lebanon, Ind. -- An innovative plan for the application of sewage sludge as fertilizer on farmland will be the subject of a public hearing on Tuesday, January 11, here, Organic Materials Corporation announced today.

J. Fred Duff of Lebanon, president of the company, said the hearing will be conducted in cooperation with the City of Indianapolis. The city's Department of Public Works has awarded a contract providing for the agricultural use of approximately 92 million gallons of treated sludge stored at its Belmont Wastewater Treatment Plant.

Duff said the hearing will be held in Boone County because farmers there have been enrolled for the program and the county will be the site of a short term, temporary holding lagoon. He said more than 75 per cent of the material will be applied to farmlands owned or operated by Duff Farm Management Services, Inc., including all of his own farmlands. Duff has operated the farm management firm since 1939 and is a past president of the American Society of Farm Managers and Rural Appraisers.

Duff said the Organic Materials Corporation land application plan will benefit both farmers and city government. It is "a scientific approach to the recycled use of nutrients in sludge, and it avoids costly problems involved in old methods of continuous storage on small land areas at treatment plants or elsewhere," he said.

The sludge's use will follow criteria developed by Purdue University agronomists, who completed chemical analysis of the material and recommended standards for a controlled land application of it, he continued. Applications will consider soil and crop needs of each farm tract, and all material applied will be disced in or plowed down within 72 hours of application, he said.

The public hearing will open at 9:15 a.m. in the Boone County 4-H Club Building at the south edge of Lebanon. The meeting will follow standards established by the U.S. Environmental Protection Agency. Documents related to the project are available for public examination at the company's offices in the Lawler Building, 122 East Washington Street, Lebanon.

Duff said details of the plan are familiar to Boone County farmers and others who witnessed a demonstration of it on November 25, 1975. He said the material will be applied only on lands of farmers who have ordered it. Because of the savings in costs normally incurred for fertilizers, "the farmers are buying it because it is a good deal for them," he added.

Explaining the use of the temporary lagoon, Duff said most of the material will be transported from Indianapolis for immediate land application. Lesser amounts transported on days of inclement weather will require placement temporarily in the lagoon, he said.

The sludge's primary nutrients are nitrogen, phosphorus and potassium. It is made up of five to 10 per cent solids and will be applied over approximately 5,600 acres at a rate of four dry tons per acre, or at a depth of approximately one-half an inch. The material has been stored for 10 to 50 years in eight lagoons at the Belmont Avenue plant in Indianapolis.

Organic Materials Corporation is a sub-contractor to Tousley-Bixler Construction Company of Indianapolis for site-preparation work making way for an expansion of the city's wastewater treatment facilities.

Farmers who have entered contracts for the use of the material in 1977 are in Center, Clinton and Eagle Townships in Boone County. The farmlands are in portions of Sections 15-22-16-23 in Center Township, portions of Sections 22-32-33-27-5-4-6-8-9 in Clinton Township, and portions of Sections 7-8 in Eagle Township.

RADIO ADVERTISEMENT

Organic Materials Corporation November 19, 1975

The following was used by WNON, Lebanon, IN on November 19, 1975

This is a message of great importance to all farmers. A liquid fertilizer that can cut your costs by at least two thirds. Thats right - at least a two-third reduction in your liquid fertilizer costs. The Organic Materials Corporation of Lebanon invites all cost conscious farmers to see a demonstration of the application of this product at the Duff Farm this coming Tuesday. The basis of this product is sludge - that's right - sludge. But's it's acceptable - there's no odor problem - it does the job efficiently and it can cut your costs to a great extent. The application is being used effectively in many areas of the state. You just can't afford to miss this demonstration with a full line of equipment. The demonstration will be at the Duff Farm- 2 miles north of State Road 32 on 400 East. That's the intersection of County Road 400 East and 200 North. Tuesday, November 25th from 10 to 2. Tuesday from 10 to 2 at the Duff Farm.

NEWSPAPER ARTICLES

The following article appeared in the Lebanon Reporter on October 30, 1975.

PUBLIC HEARINGS SLATED ON BOONE SLUDGE OPERATION

A hearing is expected to be slated within a month on the proposal by Organic Materials Corporation for the construction of a lagoon in northwest Boone County and the utilization of sludge as registered fertilizer on farm land in Boone County.

John Tait of Noblesville, a fulltime employee of the corporation and one of the directors, stated today that the Indiana Stream Pollution Control Board, Boone County Board of Health, Indiana State Board of Health, Boone County Planning Commission and possibly the Environmental Protection Agency would be involved in the hearing which is open to the public. The date of the hearing will be announced later. The recently formed corporation is headed by well known Lebanon resident J. Fred Duff. The firm is proposing the establishment of a lagoon for the treatment of the sludge near State Road 47, about quarter to one-half mile west of US 421 on the south side of the state highway. The land, consisting of 120 acres, is being purchased at present on contract by Rene O. and Barbara Hoffman from Herbert Hoover and adjacent property is owned by Myron Lyon. The corporation has options to buy the land.

Tait said the lagoon would consist of five to eight acres. In conferring with farmers in the area, "We have found no objections and even have letters of intent to purchase the fertilizer as soon as we can make it available," Tait said.

Boone Planner Bruce Stauffer saw the plans yesterday and said that he had not had time to analyze them, but that his first thoughts would be on zoning, if it is to be a commercial plant.

However, Dave Richey, attorney for the organization, said that his opinion, based on an Illinois Supreme Court ruling on a similar situation, is that the land would not have to be rezoned as its usage would still be that of agriculture.

The organization has been working on the project for over two years. It has worked closely with Purdue University which has made analysis of this material.

"We have agreed to completely follow the recommendations of the Agronomy Department of Purdue as to rate of application on farmlands and to follow to the letter all recommendations of the Indiana State Board of Health," Tait said.

The fertilizer, which is to be registered with the state of Indiana and a trade name acquired, contains primarily nutrients of nitrogen, phosphorus and potassium and can be applied at $22 an acre compared to $110 for other fertilizer, according to Tait.

The main headquarters are to be located in Lebanon. A site for offices is being studied and the potential number of employees is about 25, including office personnel. "We would have six vehicles, flotation type, to apply the treated sludge and would work six days a week, two shifts a day. The lagoon would be fenced in and we would have a 24-hour, seven-day watch with a mobile guard home at the lagoon site."

Tait further indicated that soil engineers are checking soils to assure that there will be no leaching on surface or subterranean levels. If this does propose a problem, then the lagoon would be completely encased or sealed.

Further, Organic Materials Corporation hopes to acquire from the city of Indianapolis 100-million gallons of sludge, now resting in lagoons at the Belmont Avenue sewage plant, and have the operation going by January. The firm also plans to contact the Lebanon Utilities which now has a yearly contract for disposal of its sludge with Art Casper of Crawfordsville.

Indianapolis officials want to remove the sludge from its lagoons and close them to permit expansion of the existing sewage-treatment facility. It is estimated that it would take one to two years to remove this sludge.

The sludge would be stored in the proposed Boone lagoon for a minimum of one year so that when application is made there is no odor.

"We are interested in any group wanting to learn about this project and will bring in experts or others to talk and show study facts and findings," Tait assured. "We are not trying to hide anything. We want the public to know what we propose to do and how it will benefit the farmers and others."

The following article appeared in The Lebanon Reporter on November 20, 1975.

ORGANIC MATERIALS TO HOLD LIQUID FERTILIZER DEMONSTRATION

As interest and concern mounts over a proposed sludge lagoon in Boone County, Organic Materials Corporation announced today that the public is invited to a demonstration for application of the liquid fertilizer.

The demonstration will be held Tuesday, November 25, from 10 a.m. to 2 p.m. two miles north of State Road 32 on County Road 400 East or three miles south and one mile west of Elizaville (State Road 47) at intersection of County Roads 400 East and 200 North.

J. Fred Duff is president of Organic Materials Corporation which is proposing a holding lagoon in Marion Township on some 120 acres of land on which they have taken an option.

A hearing to explain the facility was set for December 5, however this has been cancelled.

According to Bruce Stauffer, Boone area planner, the hearing to be conducted by the Indiana State Stream Pollution Control Board and the Indiana State Department of Public Health is not necessary because there

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are already 37 similar lagoons in operation in the state utilizing sludge and no problems are indicated as to environmental status.

Neither Duff nor other officers of Organic Materials nor Indiana Stream Pollution Control authorities were available for comment, at press time.

Stauffer indicated earlier this week that he was of the opinion that a reckoning of the land from agriculture to commercial might be necessitated since the corporation proposes to sell the liquid fertilizer to farmers.

Today, he stated, "I have not changed my opinion at this time, however, I am open to various legal opinions and consultations. The ultimate decision will rest with the Planning Commission."

As to the operation of the proposed facility to be located west of U.S. 421 on the south side of SR 47, "this is not my bailiwick" Stauffer noted. He did add that Organic Materials has made a concentrated and concerted study of the operation and presented a complete, encompassing study of all aspects incorporating studies and suggestions from Purdue University, even down to the most ideal and suitable rate of application per acre, based on soil content. He further noted that Organic Materials has assured that there will be no leaching, even if a walled lagoon is necessitated.

Earlier it had been reported that the December 5 hearing was cancelled because Indianapolis was not going to sell its sludge from the Belmont Street Sewage Treatment plant to Organic Materials. This could not be verified from the Indianapolis Public Works, Liquid Waste Division.

Stauffer further explained that the proposed Boone site would merely be used as a temporary holding facility, not a treatment plant.

The Organic Materials Corporation had offered to buy the sludge from Indianapolis and bring it to Boone, firm officials noting that it would be beneficial and economical for area farmers. This is only a small aspect of a $183 million project federally funded, under which EPA has told Indianapolis that it must build a sophisticated sewage treatment plant at the Belmont Avenue site, necessitating a new building which Indianapolis wants to place adjacent to the existing facility and would be over the lagoon site. Thus, the sludge must be cleared out.

Stauffer further pointed out that there are two stages, biologically, of the sludge from sewage plants. The first is a bacterial breakdown causing release of gaseous odor. After a nine-month to year holding, the sludge has no significant odor.

The pre-held sludge would be removed and whenever weather permits applied directly to fields. Application is not done during rains or when soil is frozen. The sludge is held in lagoons during these periods.

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GENERAL INFORMATION

Organic is an Indiana Corporation with corporate headquarters in Lebanon, Indiana. All of the shares of the Company are owned by eight Indiana residents, all of whom have skills which will assist in plans and growth. Two years of extensive planning and research had been done before its incorporation.

The Corporation expects to be the successful bidder for the removal and disposition of one hundred million plus gallons of seasoned treated sewage sludge from storage lagoons located in the City of Indianapolis. In the future other bids to other Indiana cities will be made.

What are the benefits possible from the use of this material, and what are the limitations or restrictions regarding its use?

9-1/8"

TYPICAL ANALYSIS

Purdue University through the Agronomy Department made an analysis of sludge samples from two different levels at two separate locations from each of ten lagoons. Dr. Lee Sommers of Purdue has completed a detailed report. (A full copy of this report is available at your request.)

Since the samples analysed were from ten different lagoons that were filled and stored over a period of the last fifty years, the chemical characteristics varied slightly from lagoon to lagoon. The solids content also varied from one lagoon to another.

Before removal of any material for transportation for farmland application, a separate chemical analysis for each lagoon will be made. A registration of this material as a fertilizer with the State Chemist will insure that the stated nutrient content will be present.

Tables number three and four from the Purdue report show the recommended maximum application for various type soils, the available nutrients, and the amounts of additional chemical fertilizers which would be required for various crops for various desired yields. The nutrient values shown on table 4 are based upon the application of four (4) dry tons per acre of liquid sludge. If the material is 10% solids, this represents an application of ten thousand gallons per acre, or slightly more than 1/3 of an inch.

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From table 4, the primary nutrients applied per acre would be:

Nitrogen, (available) 125 pounds
Phosphorous - 207 pounds (Since this is Pure P, it is the equivalent of approximately 1000 lbs of 0-46-0 Super Phosphate)
Potassium 17 pounds

Based upon the crops to be planted and yields sought, more N and K might be required and an excess of P would be present.

The Purdue table would indicate that the most economical use of this material would be only every second or third year with N and K only used by the farmers in the years our product was not applied.

COST

The cost of this material applied by high flotation vehicles will be $22.00 per acre throughout 1977. The terms will be:

> Five per cent (5%) cash discount for payments received within ten days of the completion of any applications.
>
> If the ten day cash discount is not used, payments may be made anytime prior to January 15, 1978, without penalty, interest, or carrying charges for 1977 applications.

ODORS

The material proposed has been stored in lagoons. The primary source of odors from sludge is the partial denitrification that takes place in the first nine months of storage. The odor, if any, of the material in the lagoons could best be described as a musty earthy odor. As the material is removed from the lagoons, and if the lower level stored material has an offensive odor, discing in of material within twenty-four hours of its application would be done by the Corporation without additional charge.

GOVERNMENTAL REGULATION

The Indiana State Board of Health, and possibly the United States Environmental Protection Agency will require that strict guidelines be followed. All such guidelines plus the recommendations of Purdue University will be complied with.

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PROPERTY DAMAGE, PRODUCT LIABILITY

A ten million dollars ($10,000,000.00) insurance policy by a major insurance company is carried by Organic covering any property damage or possible damages resulting from the use of this material. A representative of Organic will meet within twelve (12) hours with any farmer who makes a complaint.

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We are seeking your ideas, or suggestions, on methods the company plans to use. Your criticisms will be just as welcome as your praise, as we are interested in initially performing an efficient beneficial service with a goal of constant improvement. Please write or call us.

Sincerely,

6-1/2"

JFD/nb

9-1/8"

Attachment:

Table 3
Table 4
Agronomy Guide - Disposal of Sewage Sludge on Cropland
by J. V. Mannering, D. W. Nelson and
L. E. Sommers, Agronomy Department

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APPENDIX C

LETTER OF INTENT

LETTER OF INTENT

Organic Materials Corporation, an Indiana corporation with principal office in Lebanon, Indiana ("Organic"), has presented a program to me/us for application of seasoned, lagooned sewage sludge (sometimes referred to as "material") on the farms owned, managed or operated by the undersigned.

A representative of Organic has explained that bidders other than Organic Materials may be awarded the contract for such removal and disposition. If Organic is unsuccessful in its bid or the sludge is otherwise unavailable, this Letter of Intent is void.

I/we acknowledge receipt of this Letter of Intent together with a form of Release to be signed by me/us, and also the following items:

1. The chemical analyses made by the United States Environmental Protection Agency "EPA") and Moseley Laboratories, Inc. of samples of material from the Indianapolis Belmont Avenue Wastewater Treatment Plant, lagoons one (1) through eighteen (18).

2. A copy of the Environmental Assessment submitted with Organic's bid as a subcontractor on EPA Project No. C-180747-02. This Environmental Assessment includes certain chemical analyses of samples of material from the Indianapolis Belmont Avenue Wastewater Treatment Plant lagoons one (1) through ten (10) by:

   a. The Indiana State Board of Health Water Laboratory.
   b. Purdue University.
   c. Jones and Henry Laboratories, Inc.
   d. O. A. Laboratories.
   e. Moseley Laboratories, Inc.

3. The Environmental Assessment also includes information specifying the amount of material to be applied per acre for various crops and different types of soils prepared by the Purdue University Agronomy Department.

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4. A bottle of sewage sludge from the Indianapolis Belmont Avenue Wastewater Treatment Plant lagoons. (The undersigned understands that the sewage sludge contained in such bottle may not be a representative sample of the sludge actually applied.)

5. Also included in the Environmental Assessment is a description of the methods which Organic Materials Corporation expects to use in the application of this material. Certain restrictions on rate of application and manner in which material may be applied are to be followed scrupulously.

I/We understand that a public hearing was held in Boone County on January 11, 1977, regarding this program and that a copy of the hearing transcript, hearing exhibits and post-hearting exhibits are available for inspection by the undersigned at the principal offices of Organic, 124 East Washington Street, Lebanon, Indiana 46052.

I/We recognize and understand that the material's chemical content (including, but not limited to, nutrients and metals) and the material's liquid percentage may vary somewhat since the material has been stored in eighteen (18) different lagoons for different lengths of time. I/We further recognize and understand that the material applied on my/our farmlands may be taken from any one of lagoons numbered one (1) through ten (10), or lagoons numbered eleven (11) through eighteen (18) if these additional lagoons should be made a part of Organic's contract.

It is expressly understood that prior to any application of material I/we will be given a copy of a Certificate of Insurance issued to Organic in an amount of not less Fifteen Million Dollars ($15,000,000) and among its provisions will include general liability and property damage.

Soil samples of my acreage will be taken for an analysis by Purdue University for pH&CEC: These tests will be made without cost to me/us. It is understood that the optimum utilization of this material is as shown in Table 3 of Purdue University's chemical analysis and recommendations contained in the Environmental Assessment. No application in excess of the amounts shown on this table will be made by Organic.

The "INTERIM GUIDELINES FOR MUNICIPAL SLUDGE DISPOSAL ON LAND, NOVEMBER 1975 SWK, INDIANA STATE BOARD OF HEALTH" and Purdue University's recommendations (both contained in the Environmental Assessment) require that a minimum soil pH of 6.5 is required on any lands where sludge is to be utilized. It is agreed that the cost of any lime up to three tons per acre necessary to increase the pH of the soil to 6.5 will be shared equally by Organic Materials Corporation and

I/we. Organic's portion of this cost to be deducted from my/our $22.00 per acre cost.

The total cost of this material applied in the maximum quantities shown in Tables 3 and 4 will be $22.00 per acre for acreage applied anytime in the year 1977.

Terms: 10% cash discount for payments received within ten days of the completion of any application.

If the cash discount for payment in ten days is not used, payments may be made anytime prior to January 15, 1978 without penalty.

I/we agree to disc in all material applied within seventy-two hours of its application (UNLESS WEATHER MAKES THIS IMPOSSIBLE). ORGANIC WILL DISC IN THIS MATERIAL IF I/WE DO NOT DO SO AT AN ADDITIONAL COST OF THREE DOLLARS AND FIFTY CENTS ($3.50) PER ACRE.

Organic may file with the Boone County Recorder's Office information regarding application of material on my/our farmlands. Any filing fees in connection with such filing shall be paid entirely by Organic.

It has been explained to me/us that a joint program of determining farming community and general public attitudes may be conducted by Purdue University or Organic Materials Corporation. That as an inducement to me/us, the undersigned, to participate in such an attitude study, these materials will be available at a fraction of the handling and application costs in 1977 to those willing to participate. The minimum and maximum time required for such participation will be one hour unless at my/our choice it is agreed to extend the one-hour period.

This participation will consist of the following:

a. Agreement to meet at my/our home with a representative of Purdue University or Organic Materials Corporation within one week after the material has been applied to my/our acreage and faction; suggestions as to how the material could be more effectively applied, or any criticisms I/we might have. No use of our names would be made without our specific approval in writing.

b. A similar interview will be made after the crops are harvested from the areas where the material has been used. I/we would be asked for frank opinions, suggestions for improvements and criticism. Our name without our specific approval would not be used or identified in any way.

The purpose of such a study is to analyze the results for improvement of methods and to publish the results of such a study to assist in formulating guidelines for such applications in other parts of the United States.

I/we hereby state my/our intent to use the above described materials supplied and applied by Organic Materials Corporation, subject to all of the provisions outlined previously in this Letter of Intent.

The number of acres where this material will be utilized in 1977 are

Date: ____________________________

The farmlands are located in Section(s) ____________________,

____________________________ Township, Boone County, Indiana.

________________________________	________________________________
Representative of Organic Materials Corporation	Farm Owner/Operator
	________________________________
	Address
	________________________________
	Phone Number

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APPENDIX D

RELEASE FORMS

APPLICATION

RELEASE

The undersigned (party) (parties)* having an interest, as indicated below, in property, or crops on said property, upon which sludge removed from the Belmont Treatment Plant of the City of Indianapolis is to be applied, acknowledge(s) that results of analyses of the sludge material being applied, made by U.S. Environmental Protection Agency and Moseley Laboratories Inc. (and other analyses by Purdue University, O. A. Laboratories, Jones and Henry Laboratories, Inc. and Indiana State Board of Health Water Laboratory) have been made available to and have been reviewed by them, but that it is impossible to know the exact contents of all of the sludge material or the possible effects of the sludge material and its contents upon land, personal property, crops, animals or human beings. The undersigned further acknowledges that he is knowledgeable of the public hearing held on January 11, 1977, regarding the proposed use of such sludge in Boone County.

It is understood that Organic Materials Corporation is the sole owner of such sludge materials. Therefore, in consideration of being permitted to purchase said sludge from Organic Materials Corporation, the undersigned (does) (do)* hereby release the State of Indiana, the City of Indianapolis, the City's Project Engineer, the Project Engineer's Consultants, and their agents and employees from and against all claims, damages, losses and expenses including attorneys' fees arising out of or resulting from the application of such sludge materials, including claims based upon the negligence of the released parties. Furthermore, any such claims, damages, losses and expenses arising out of or resulting from the application of such sludge materials, including any damage to fences or buildings, are the sole responsibility of Organic Materials Corporation.

The said property upon which sludge is to be applied is identified on the U. S. Department of Agriculture, Soil Conservation Service, soil survey map(s) of Boone County, Indiana and the aerial photograph(s) attached hereto and incorporated herein by reference.

(Signature)	(Signature)
(Printed)	(Printed)
Interest in Property and/or Crops	Interest in Property and/or Crops

*Strike inapplicable words.

STORAGE

RELEASE

The undersigned (party) (parties)* having an interest. as indicated below, in property, or crops on said property, upon which sludge removed from the Belmont Treatment Plant of the City of Indianapolis is to be stored, acknowledge(s) that results of analyses of the sludge material being stored, made by U.S. Environmental Protection Agency and Moseley Laboratories Inc. (and other analyses by Purdue University, O. A. Laboratories, Jones and Henry Laboratories, Inc. and Indiana State Board of Health Water Laboratory) have been made available to and have been reviewed by them, but that it is impossible to know the exact contents of all of the sludge material or the possible effects of the sludge material and its contents upon land, personal property, crops, animals or human beings. The undersigned further acknowledges that he is knowledgeable of the public hearing held on January 11, 1977, regarding the proposed use of such sludge in Boone County.

It is understood that Organic Materials Corporation is the sole owner of such sludge materials. Therefore, in consideration of being permitted to purchase said sludge from Organic Materials Corporation, the undersigned (does)(do)* hereby release the State of Indiana, the City of Indianapolis, the City's Project Engineer, the Project Engineer's Consultants, and their agents and employees from and against all claims, damages, losses and expenses including attorneys' fees arising out of or resulting from the application of such sludge materials, including claims based upon the negligence of the released parties. Furthermore, any such claims, damages, losses and expenses arising out of or resulting from the application of such sludge materials, including any damage to fences or buildings, are the sole responsibility of Organic Materials Corporation.

The said property upon which sludge is to be applied is identified on the U.S. Department of Agriculture, Soil Conservation Service, soil survey map(s) of Boone County, Indiana and the aerial photograph(s) attached hereto and incorporated herein by reference.

(Signature)	(Signature)
(Printed)	(Printed)
Interest in Property and/or Crops	Interest in Property and/or Crops

*Strike inapplicable words.

APPENDIX E

FORMS AND MAPS USED TO IDENTIFY SLUDGE APPLICATION SITES

SLUDGE FIELDS AND LAND OWNER IDENTIFICATION

Belmont Waste Treatment Plant Sludge Application

Owner	Corn, John	Tenant	
Address	R. R. 1 Lebanon, Indiana 46052	Address	
Telephone	123-4567	Telephone	

OWNER IDENTIFICATION NO. 13

FIELD INFORMATION AND IDENTIFICATION

Field No.	Broadcast Acreage	Injection Acreage	Location
13-1	49.2	12.9	RIE T19N Sec 23 Center Township
13-2	40.0	0	RIE T19N Sec 23 Center Township
13-3	11.3	9.8	RIE T19N Sec 23 Center Township

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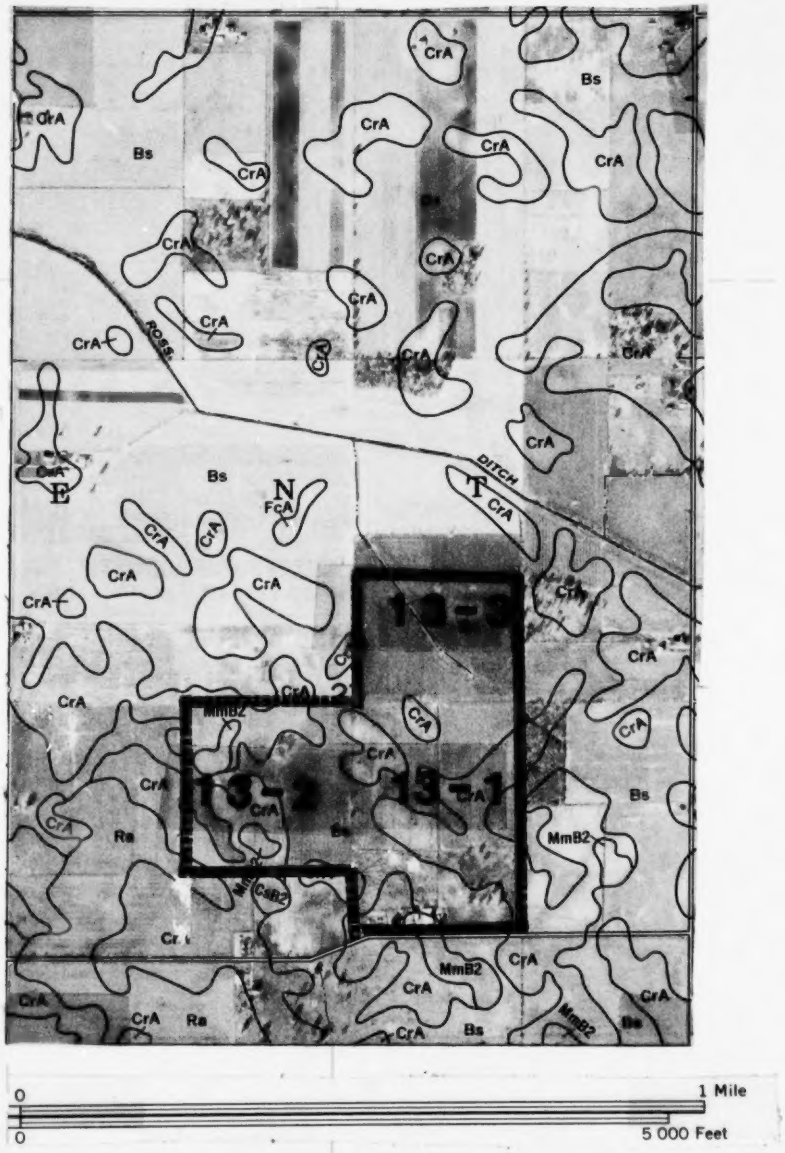
EXAMPLE SOIL SURVEY MAP WITH FIELD IDENTIFICATION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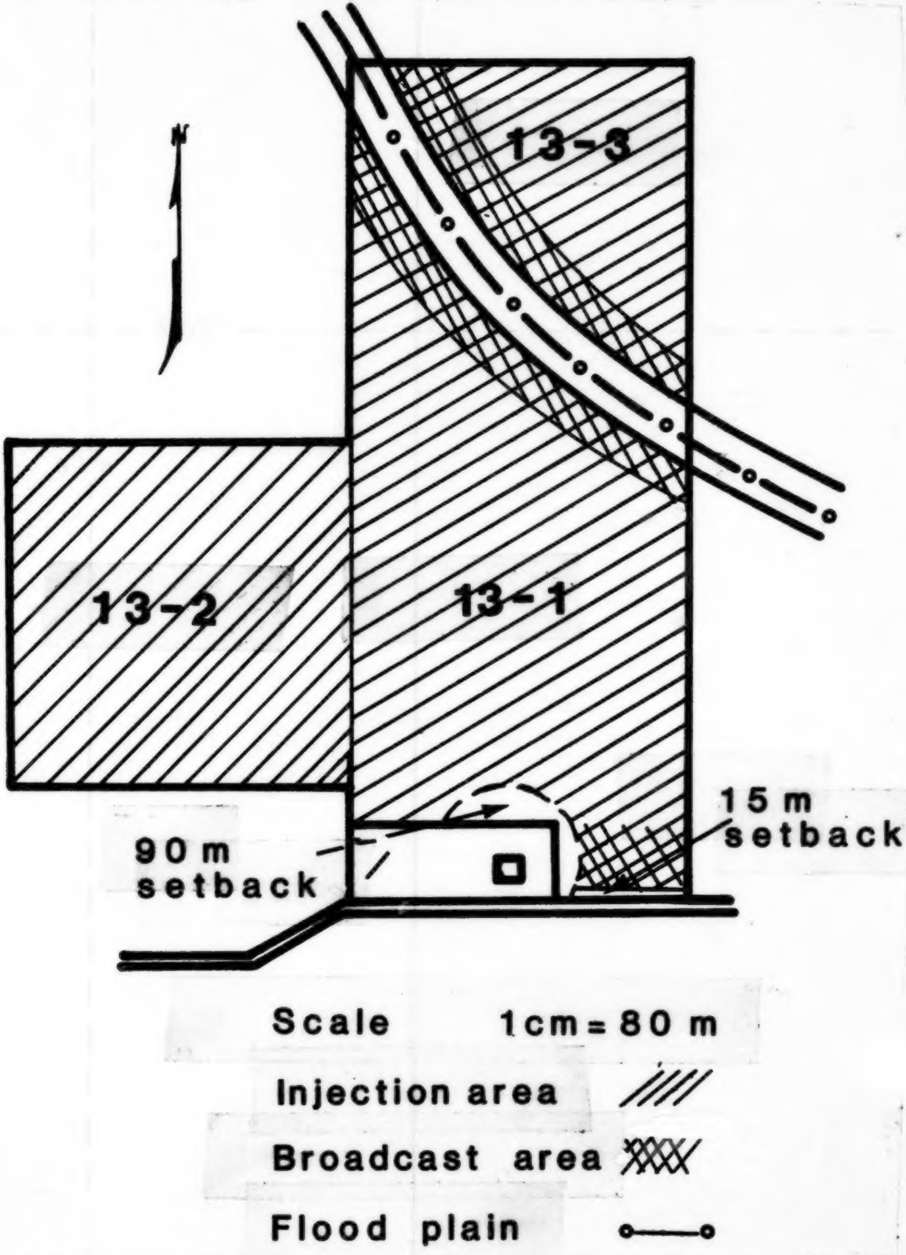
KEY TO SOIL SURVEY MAP(SEE MAP ON PAGE 93)

Map Symbol	Mapping Unit
Br	Brookston silt loam, overwash
Bs	Brookston silty clay loam
CrA	Crosby silt loam, 0 to 3 percent slopes
CsB2	Crosby-Miami silt loams, 2 to 6 percent slopes, eroded
FcA	Fincastle silt loam, 0 to 3 percent slopes
FsA	Fox silt loam, 0 to 2 percent slopes
FsB2	Fox silt loam, 2 to 6 percent slopes, eroded
FsC2	Fox silt loam, 6 to 12 percent slopes, eroded
Gn	Genesee silt loam
HeF	Hennepin loam, 25 to 50 percent slopes
Ma	Mahalasville silty clay loam
MaA	Miami silt loam, 0 to 2 percent slopes
MmB2	Miami silt loam, 2 to 6 percent slopes, eroded
MmC2	Miami silt loam, 6 to 12 percent slopes, eroded
MmD2	Miami silt loam, 12 to 18 percent slopes, eroded
MmE2	Miami silt loam, 18 to 25 percent slopes, eroded
MsB3	Miami silt loam, 2 to 6 percent slopes, severely eroded
MsC3	Miami silt loam, 6 to 12 percent slopes, severely eroded
MsD3	Miami clay loam, 12 to 18 percent slopes, severely eroded
OcA	Ockley silt loam, 0 to 2 percent slopes
OcB2	Ockley silt loam, 2 to 6 percent slopes, eroded
Ra	Ragsdale silty clay loam
Re	Reesville silt loam
Sh	Shoals silt loam
St	Sleeth silt loam
Sx	Sloan silt loam
We	Westland silty clay loam
Wh	Whitaker silt loam

IDENTIFICATION OF SURFACE AND INCORPORATION AREAS FOR SLUDGE APPLICATION ON THE EXAMPLE SOIL SURVEY MAP.


N
13-3
13-2
13-1
90 m setback
15 m setback
Scale 1cm = 80 m
Injection area
Broadcast area
Flood plain

EXAMPLE OF SOIL TEST DATA

Name: John Corn

	Sample No. 1	Sample No. 2	Sample No. 3
Organic matter, %	3.2	4.4	2.7
Available P, ppm	46	21	24
Available K, ppm	182	92	83
Magnesium, ppm	410	640	610
Calcium, ppm	2,100	3,400	3,050
Water pH	6.5	6.7	6.9
Buffer pH	6.8	---	---
Cation exchange capacity, meg/100 g	15.6	23.7	20.8
Total Zn, ppm[a]		4.5	
Ni, ppm		32	
Cd, ppm		0.4	
Cu, ppm		22	
Pb, ppm		11.2	

[a] Composite sample

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APPENDIX F

FORMS USED TO MONITOR SLUDGE REMOVAL, TRANSPORTATION, AND APPLICATION

FORM A - SUMMARY OF SLUDGE APPLIED TO A GIVEN AREA(CONSTANT APPLICATION RATE)

Owner & field #____________________

Injection Acres __________ Broadcast Acres__________ Total Gallons

Total Acres __________ Application Rate_________ Needed__________

Date	Time	Trip Ticket # Dispatched	Gallons Dispatched	Relocation/ Trip Ticket #	Relocated

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FORM B - SUMMARY OF SLUDGE APPLIED TO A GIVEN AREA(ALL APPLICATION RATES)

Owner & Field #____________________ Date Lime Applied____________ Date Disced________________
Injection Acres __________________ Broadcast Acres________________
Total Acres____________________ Application Rate__________________ Total Gallons Needed__________

GALLONS RECEIVED				GALLONS APPLIED				
Date	Time	Trip Ticket # Received	Gallons Received	Spreader or Injector #	Gallons Applied	Spreader or Injector #	Gallons Applied	Comments

TOTAL GALLONS RECEIVED ____________

TOTAL GALLONS BROADCAST________________

TOTAL GALLONS INJECTED________________

FORM C - DAILY SUMMARY REPORT OF SLUDGE REMOVED

DAILY REPORT SHEET OF SLUDGE REMOVED FROM BELMONT AVENUE LAGOONS AND DESINTATIONS

Date:___________________

Lagoon Number	Owner & Field #/ Lagoon #	Trip Ticket #	Gallons Applied	Sludge Stored in Temporary Lagoon	Gallons Transported

TOTAL LOADS

TOTAL GALLONS APPLIED

TOTAL GALLONS TEMPORARILY STORED

TOTAL GALLONS TRANSPORTED

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FORM D - WEEKLY SUMMARY REPORT OF SLUDGE REMOVED

WEEKLY REPORT SHEET OF SLUDGE REMOVED FROM BELMONT AVENUE LAGOONS

WEEK ENDING:_______________

Date	Total Loads	Total Gallons Applied	Total Gallons Transported	Total Gallons Temporarily Stored
WEEKLY TOTAL LOADS				
WEEKLY TOTAL GALLONS APPLIED				
WEEKLY TOTAL GALLONS TRANSPORTED				
WEEKLY TOTAL GALLONS TEMPORARILY STORED				

FORM E - MONTHLY SUMMARY REPORT OF SLUDGE REMOVED

MONTHLY REPORT SHEET OF SLUDGE REMOVED FROM BELMONT AVENUE LAGOONS

MONTH ENDING:________________

Week	Total Loads	Total Gallons Applied	Total Gallons Transported	Total Gallons Temporarily Stored
MONTHLY TOTAL LOADS				
MONTHLY TOTAL GALLONS APPLIED				
MONTHLY TOTAL GALLONS TRANSPORTED				
MONTHLY TOTAL GALLONS TEMPORARILY STORED				

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APPENDIX G

OBSERVATION OF LAND APPLICATION OF SLUDGE

The following was a list of items considered in developing an observation program.

A. Information needed on trucks leaving Belmont Plant:

1. Truck number or other truck designation.
2. Time leaving Belmont Plant.
3. Destination of truck: farm or lagoon.
4. Check that farm has had clearance.
   (a) List of approved farms.
   (b) If lagoon, no clearance noted, except that lagoon is completed.
5. List number of lagoon from which sludge was removed.
6. Total suspended solids concentration.
   (a) Based on total suspended solids of lagoon, calculate and record the allowable spreading rate (gallons/acre).
   (b) Acreage covered by applicator vehicle.
7. All the above information on multiple copy ticket with one copy delivered to off-site observer.

B. Periodic Total Suspended Solids Analysis:

1. Contractor is to start with a minimum of four (4) samples per shift/lagoon.
2. Grab samples should be taken periodically for analysis by independent lab in accordance with City's contract (one day turn around on samples).
3. Duplicate samples collected by contractor should be run by independent lab, especially at the beginning, to determine any variations.

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4. Consulting firm will run periodic solids analyses on-site.

C. Information and procedures at the application site:

1. Observer takes ticket from dirver and marks arrival time.
2. Observer determines application area for sludge based on volume of applicator vehicle and allowable application rate.
3. Observer checks setbacks on land from high water level, inhabitant dwellings, wells, roadways, checking area for injection and broadcasting.
4. Check weather and land conditions. Make sure they meet the requirements for spreading.
5. Observer should note the type ofland being applied to - plowed, disced, pasture land, crops, etc.
6. Check for discing within 72 hours.
7. Fill out daily tally sheet.

D. At the lagoon for incoming sludge:

1. Tickets collected - locate lockbox for driver to insert information in as he delivers the sludge.
2. Occasional check of level in lagoon.

E. At lagoon for outgoing sludge:

1. Must have up-to-date cadmium analysis of sludge if taken from more than one Belmont lagoon or use highest concentration of cadmium for application rate determination. Suspended solids concentration needed as at Belmont Plant.
2. Approximately same information needed as for sludge leaving the Belmont Plant site.

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APPENDIX H

SUMMARY OF SPECIFICATIONS FOR THE SLUDGE SPREADING EQUIPMENT USED ON THE PROJECT

FIELD GYMMY

Manufactured by: - Field Gymmy Incorporated
P. O. Box 121
Glandorf, Ohio 45848

Engine - V-8, gasoline, 220 net H.P.

Transmission - Automatic

Steering - Full power

Brakes - Four Wheel, power

Front tires - 48 x 25.00 x 20, 6 ply, Goodyear Terra Tread

Rear tires - 66 x 33.00 x 25, 6 ply, Goodyear Terra Tread

Four Wheel Drive - Yes

Sludge Tank Capacity - 2000 gallon

Vacuum/pressure pump - 192 cfm

Subsurface Sludge Applicator - 3 shank, hydraulically controlled

TERRA GATOR 2505

Manufactured by:	Ag-Chem Equipment Co., Inc. 4900 Viking Drive Minneapolis, MN 55436
Engine	- Turbo-charged 350 HP Cummins Diesel
Transmission	- 10 speed, heavy duty manual
Steering	- Full power
Brakes	- Air over hydraulic power
Front tires	- 66 x 43.00 x 25, 6 ply, Goodyear Terra Tread
Rear tires	- 66 x 43.00 - 25, 6 ply, Goodyear Super Terra Tires
Four Wheel Drive	- Rear four-yes, front wheel-no
Sludge Tank capacity	- 3800 gallons
Vacuum/pressure pump	- 192 cfm
Subsurface Sludge Applicator	- 4 shank, hydraulically controlled

BIG A 4500

Manufactured by:	Rickel Manufacturing Corporation P.O. Box 626 3600 West Airport Road Salina, Texas 67401
Engine	- Cummins Model VT903 350HP V-8 turbo-charged diesel
Transmission	- Allison 5 speed automatic, HT 750 CRD
Steering	- Four wheel, drive, four wheel steer
Brakes	- Power (air over hydraulic)
Front tires	- 66 x 43.00 x 25, Goodyear Super-Terra tread
Rear tires	- 66 x 43.00 x 25, Goodyear Super-Terra tread
Four Wheel Drive	- Yes
Sludge tank capacity	- 3500 gallons
Vacuum/pressure pump	- 192 cfm
Subsurface sludge applicator	- 5 shank, hydraulically controlled